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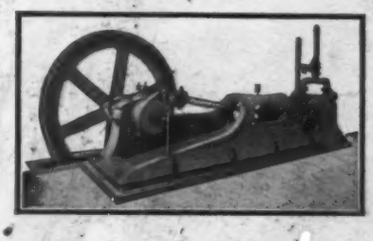

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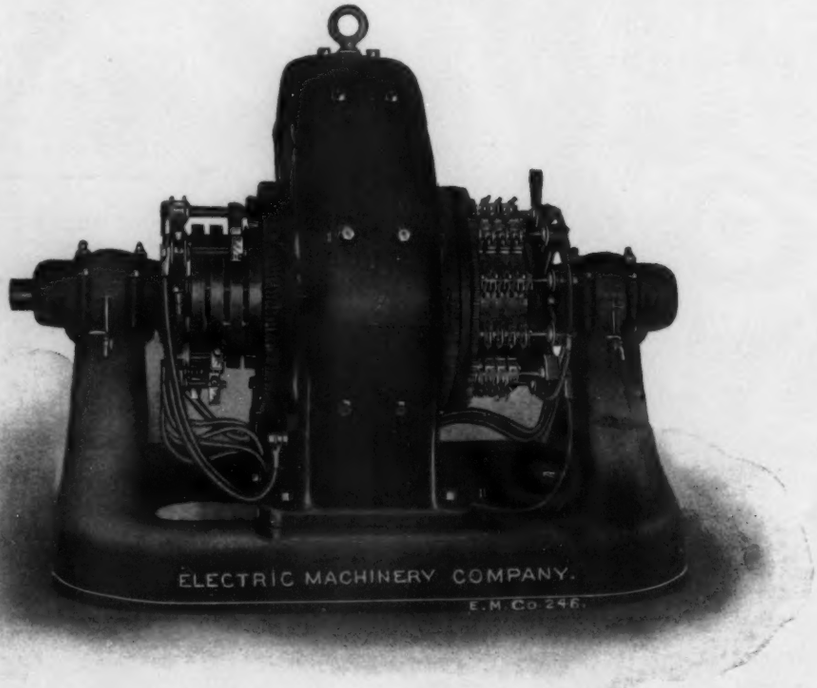

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VOLUME XV. SAN FRANCISCO, CAL., APRIL, 1905. NUMBER 4

*Use of Pacific Coast Water Powers in Electrical Operation of Railroads.**

BY ROBERT McF. DOBLE.

THE activity displayed in Europe in utilizing three-phase alternating current for the operation of railways, has never been fully shared by American engineers, on account of the alleged limitations of the polyphase induction motor. In this country, during the last few years, several engineers have been working on the development of the alternating current single-phase system, and the two largest electrical manufacturing companies have gone on record to the effect that now the alternating current motor is a success for railway service.

The general opinion prevails among engineers that the third-rail as a means of collecting current is only adaptable to special conditions and that the only system which provides for a high enough voltage to give the required power is an overhead construction. The practical limit of direct current voltage on overhead conductors has been reached, but with alternating current almost any desired voltage may be used. The polyphase system is not looked upon with favor because of the two overhead wires necessary, so the single overhead wire of the single-phase system seems to be the solution of the problem.

The higher voltages possible with single-phase operation effect an economy in trolley copper. There is an increase in apparent resistance of about 50 per cent. in a single-phase trolley as compared with direct current, on account of the use of the alternating current. Therefore a voltage of 3000 or higher is necessary to secure material benefits. These higher voltages are possible as the limit seems to be only that of insulation. Overhead conductors carrying 10,000 volts have already been used, and it is stated that 18,000 volts on the trolley is being planned. Systems now in operation use voltages of about 3300 volts.

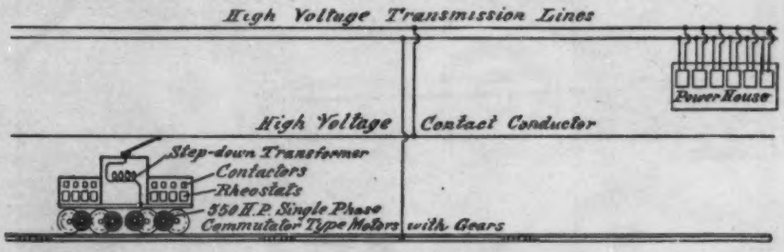


FIGURE 18. DIAGRAM OF POLYPHASE OR SINGLE-PHASE TRANSMISSION AND SINGLE-PHASE DISTRIBUTION

The original transmission to the substation is the same in the case of the alternating and the direct current systems; but by use of the higher voltage in the secondary or trolley distribution, the distances between substations can be increased. This reduces their number and increases the average load on each. As the substations consist of static transformers, the cost of and losses in the moving element—the rotary converter—are removed. This elmination of moving parts, however, does not necessarily do away with substation attendance.

Although the alternating current system effects the saving in initial cost due to the economy in trolley copper and the elimination of the rotary converter, on the other hand, the alternating current car equipment is heavier and more costly than the direct current for the same unit distance and capacity, thus offsetting much of the saving. The maintenance of the alternating current motor is higher than the direct current by reason of the higher armature speed and the smaller air gap.

An advantageous feature of the alternating current system is that the motor and its control may be arranged so as to be operated on either high-potential alternating or 600-volt direct current lines. This is an important factor in operating over city lines where the direct current system is already installed. Another advantage of the single-phase system is that the voltage can be adjusted at three places—at the power house, substation and on the car. Thus one voltage may be used in the yard, another in the suburban limits and another on the outside line. The consumption of power is directly proportional to the work done, and the speed may be varied by transformer action without breaking contacts such as are used in ordinary direct current control.

Although the above remarks indicate certain difficulties which have to be met, there seems to be no question as to the successful operation of alternating current apparatus, and it seems advisable to use it when such an installation will prove financially advantageous. A number of the factors entering into the design of the alternating current system seem to make it especially adapted to eventually replace the steam locomotive for high speed passenger and heavy freight haulage work.

Figure 18 illustrates diagramatically what is commonly known as the single-phase system, which requires a polyphase or single-phase alternating current high-voltage transmission from the power station in conjunction with a high or low voltage single-phase distribution system and high or low voltage single-phase locomotives equipped with single-phase alternating current commutator type motors geared to the axles. This system requires only one contact conductor, and the current is transformed on the car to suitable motor voltage.

The first engineer in this country to give serious attention to the merits and design of a single-phase system was B. J. Arnold, of Chicago, who, in 1899, began to develop a system, the essentials of which would be:

1. A motor which would use single-phase alternating current without conversion.
2. Single overhead working conductor.
3. Steady load upon the power house.
4. Independent unit for switching purposes.

The principles underlying the system which he developed to accomplish these results were:

a A single-phase motor mounted directly upon the car axles, designed for the average power required by the car, running at a constant speed and a constant load, and, therefore, at maximum efficiency.

b Instead of stopping and starting this motor and dissipating the energy through resistance, as was then common to all railway systems, the speed of the car was controlled by accelerating or retarding the parts usually known as the rotor and the stator by means of compressed air in such a manner as not only to regulate the speed of the car but also to store the kinetic energy of the car when stopping and utilize it in starting.

Some experimental locomotives embodying the features of this design have been built and operated on the Lansing, St. Johns and St. Louis Railway, in Michigan. However, the machine in its present form is regarded by Mr Arnold as somewhat complicated

*Conclusion of a paper read before the Pacific Coast Railway Club, at San Francisco, on January 21, 1905, and revised for THE JOURNAL by the author, the first part of which appeared in THE JOURNAL for March, 1905, page 87.

for commercial application, for like most all new mechanical problems, the first designs are somewhat more complicated than experience finds necessary. With the development of suitable rotating air machinery, it is believed that the system can be sufficiently simplified to warrant its commercial operation.

For several years the engineers of the General Electric Company have been working on this problem, and have developed a type of alternating current single-phase equipment which is believed to be suitable for general traction work. The system embodies the use of a single-phase commutator motor, and a car fitted with this apparatus has been operated in regular service by the Schenectady Railway Company on its Ballston extension. This is the first instance in this country of an alternating current road in regular service carrying passengers, and its commercial possibilities are largely due to the fact that the motors operate with alternating current power outside the city limits and with direct current power within the city limits. The motors are of the "compensated" type, and are adapted for operation on the 2000-volt alternating current trolley between cities and the standard 600-volt direct current trolley in Schenectady.

Center pole bracket construction is used, there being two brackets supporting the two 600-volt direct current trolley wires and a cross-arm supporting the two 2200-volt alternating current trolley wires. The direct current trolley conforms to standard bracket construction and presents no unusual features, while the alternating current trolley wire is suspended from a three-eighths inch steel catenary.

The engineers of the Westinghouse Electric Manufacturing Company have similarly given considerable careful attention to the design of a single-phase railway system, and have put one on the market, which, it is claimed, comprises many advantages of the direct current systems, as well as overcoming a number of its limitations. The motor used is of the "series" type and possesses all the characteristics of a direct current series motor. This system is adapted for use of voltages on the overhead conductor of 1000 volts or higher, the current being transformed on the car to suitable motor voltage.

For high voltages, a trolley of the bow type, Figure 19, is used. This is raised and lowered by compressed air under the control of the motorman, and any danger from shock in handling is thus avoided.

The overhead structure, which is of the catenary type, is illustrated in Figure 20, showing two spans. The trolley wire is suspended from a messenger cable by hangers of different lengths, so graduated that the wire is at all points parallel with the track, presenting the best possible condition for continuous contcta under high speeds.

The Westinghouse Company is now said to have under construction in its factory orders for 198 single-phase railway motors of varying size, having a total capacity of 12,000 horsepower. The sizes range from fifty to 150 horsepower. It is stated hat there will be no difficulty in building single-phase motors up to 400 horsepower for railway service. The maximum speed on the roads now being equipped is sixty miles per hour. The interurban trolley voltage runs from 1100 to 3300 alternating, and for city work from 400 to 700 volts direct current. The weights of the cars range from twenty-five to fifty tons each, including electrical equipment, and the various roads have a total length of about 200 miles of line. The longest of these roads is one from Indianapolis to Cincinnati, sixty-seven miles, which is now partially completed and will probably be extended later to about double that distance.

The trolley wire is suspended from poles 100 feet apart with a bracket made of angle iron looped at the end, so as to carry a large flat porcelain insulator, from the top of which is run a seven-sixteenths-inch steel strand cable or "messenger" wire. The No. 000 grooved copper trolley wire is carried eight inches under the messenger cable, to which it is attached every ten feet with specially made steel clamps, a construction known as the catenary suspension.

The system of electrical distribution requires transformer stations about every ten or twelve miles apart, and the alternating current is transmitted from the power house to these transformer stations at 33,000 volts, single-phase, twenty-five cycles per second, and is reduced and fed into the trolley at a potential of 3300 volts. The high-tension current is carried from the central power station to the transformer stations on No. 4 bare copper

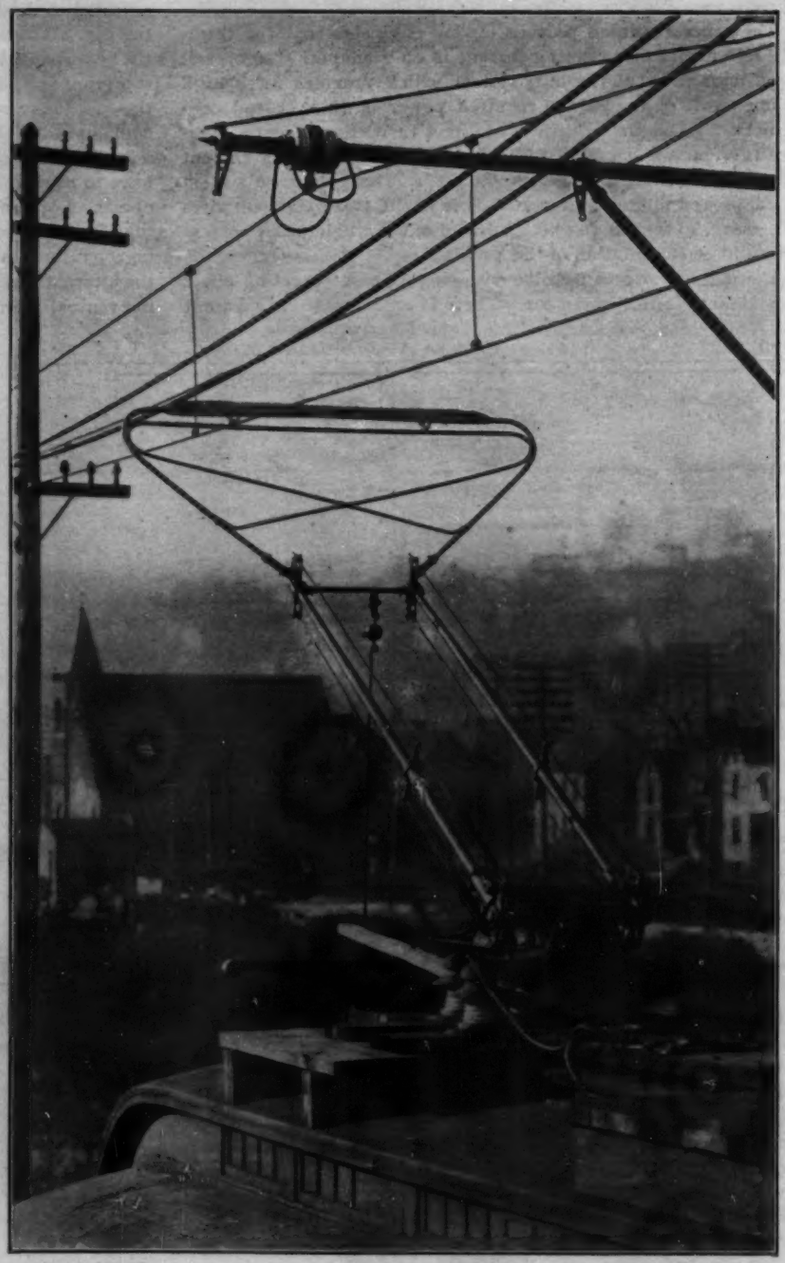


FIGURE 18. WESTINGHOUSE BOW TROLLEY AND DETAIL OF CATENARY TROLLEY CONSTRUCTION

wire on a separate line of poles, set near the edge of the right of way, equipped with large porcelain insulators on iron pins.

Within the limits of the city of Indianapolis, the cars will be run over already existing lines, and will be operated by direct current at 550 volts. Within the limits of the city of Rushville they will be operated by alternating current at the same potential; on intervening sections the trolley will be fed by alternating current at 3300 volts, twenty-five cycles per second, single-phase.

The cars measure fifty-five feet over all and are divided into three compartments for passengers, baggage and smoking. Each is equipped with four seventy-five horsepower, single-phase, alternating current motors, making 300 horsepower per car, the motors of the present equipment being geared for a maximum speed of forty-five miles per hour for local service.

To take care of the through service, "limited" cars will be put on the line designed to operate at a schedule speed of fifty or sixty miles per hour.

This road has been built in every detail with the view to the handling of heavy freight, even to the extent of carrying it in long trains.

The first installation of a single-phase railway in California is to be the Vallejo and Napa line, the track work for which has already been practically completed. This system will be of the Westinghouse type, and its installation and operation will be awaited and watched with considerable interest. It is said that there are several other railway companies on the coast which are considering the single-phase system.

Figure 21 illustrates diagramatically a system which has been practically operated on the State railway in Switzerland. It consists of a single-phase, alternating current, high voltage transmission system in conjunction with high or low voltage single-phase distribution, the locomotives being equipped with motor-generator sets which receive high or low voltage single-phase alternating current and deliver direct current at variable voltage to the driving motors, which may be of any suitable direct current type. This system is of advantage as it permits absolute control of the current for the driving motors without controllers, switches and resistances in the main circuit, and by means of this system energy may be returned to the distribution system when the train is coasting.

An announcement of importance to the advocates of the single-phase system is that the London, Brighton and South Coast Railway, extending south of London, and having an extensive network of lines carrying an enormous suburban traffic, will be electrified.

Some years ago it became apparent that something must be done to relieve the congestion on this system. Experts were secured, and after a long investigation they reported that the only thing to be done was to electrify the road. This would bring back the traffic which had been lost, and would largely increase the capacity of the terminal stations, since shunting of the trains, which causes much loss of time at the stations, would become unnecessary. At the same time, a better service could be maintained with electrically operated trains. At the time this report was made no particular system was recommended, because at that time the single-phase systems had not been fully developed, and there were practical difficulties in the way of using a direct current third-rail system. Now, however, the railway company's engineers are satisfied that the single-phase system offers a solution to all their troubles, and they have decided to adopt it.

The alternators will be driven by steam turbines and will generate twenty-five cycle current at 6600 volts. The method of distribution proposed differs considerably from any which has yet been tried. The trolley potential will be 6000 volts, double that proposed by the Westinghouse Electric and Manufacturing Company and the General Electric Company for their single-phase systems. This high voltage will not affect the motors, but will make necessary a special step-down transformer. The feeder cables will be laid underground, and each section of the trolley will be separately fed near the middle of its length. Switch gear will be provided in signal boxes controlling the feeders and for coupling sections of the conductor together in case of necessity. The running rails will not be bonded together for the return current; but each rail will be bonded to a concentric cable laid underground between the tracks, the inner conductor of the cable being the high-pressure feeder.

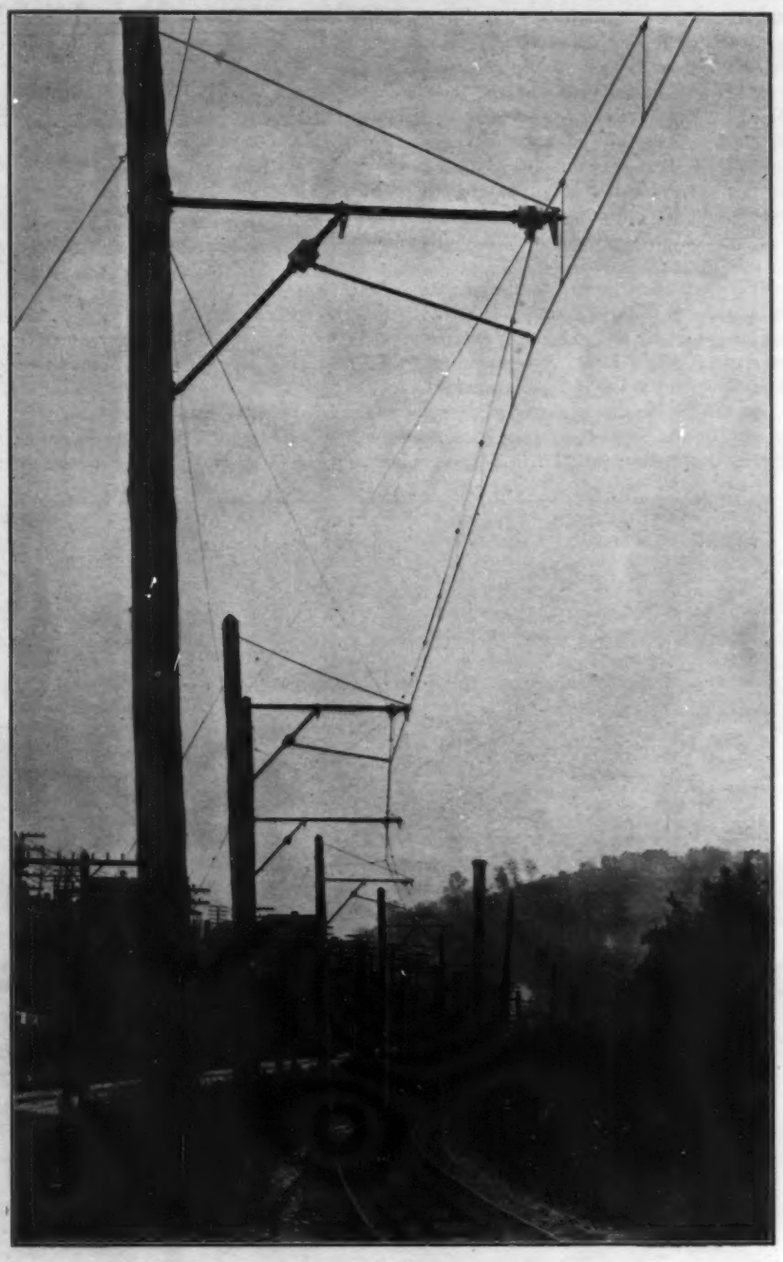


FIGURE 20.—WESTINGHOUSE CATENARY TROLLEY CONSTRUCTION

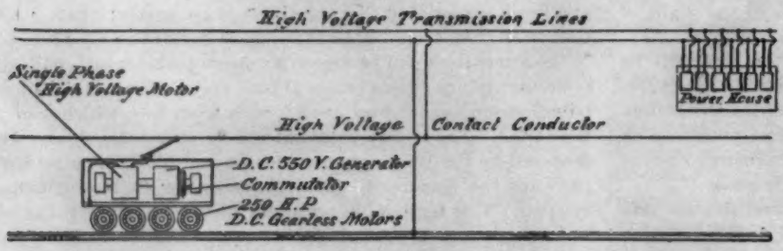


FIGURE 21. DIAGRAM OF SINGLE-PHASE TRANSMISSION WITH DIRECT CURRENT MOTORS

Figure 22 shows in diagramatic from a single-phase to polyphase system designed by J. H. Hallberg, in which the high tension current collected by the locomotive furnishes power for a single-phase synchronous or induction motor, which drives the three-phase, alternating current generator, both of these machines being of the design now commonly used in connection with steam turbines. The generator in turn supplies power for the operation of induction motors which may be of the gearless type.

With this system many advantages are claimed, an important one being that in coasting power may be returned to the distribution system, and that the absence of commutators, switching devices, resistances and gears, as well as all other delicate parts which require repair and attention, should make this type of locomotive and system commercially practicable.

It is also stated that the approximate weight of a 3000 horsepower locomotive of this type, including the motor-generator set, would not exceed 175 tons, and in case of an emergency the electric equipment could be depended upon to deliver more than 4000 horsepower.

On the Pacific Coast, the northernmost example of electric railways operated by power transmitted from hydro-electric plants is the British Columbia Electric Railway Company, which operates about fifty miles of lines in Vancouver and New Westminster from a new 12,000-horsepower generating station located sixteen miles distant on an arm of Burrard Inlet, and utilizing water from Trout and Coquitlam lakes. This plant when fully completed will have a capacity of 30,000 horsepower.

At Seattle and Tacoma, Wash., transmitted electric power is utilized for operating the local railway system, as well as the modern high-speed third-rail interurban railway which connects the two cities. The power plant is located on the Puyallup River, which is fed by the glaciers and melting snows on Mt. Rainier. This plant (which was described in THE JOURNAL for October, 1904) utilizes water under a head of 872 feet and has a capacity of 14,000 kilowatts. The power is converted and distributed to the railways through eight substations.

Another interesting use of water power for the operation of electric railways is that of the Olympia Light and Power Company, at Olympia, Wash. This company recently completed a power station on the Des Chutes River which generates 2000 horsepower and feeds the railway system directly from the power house.

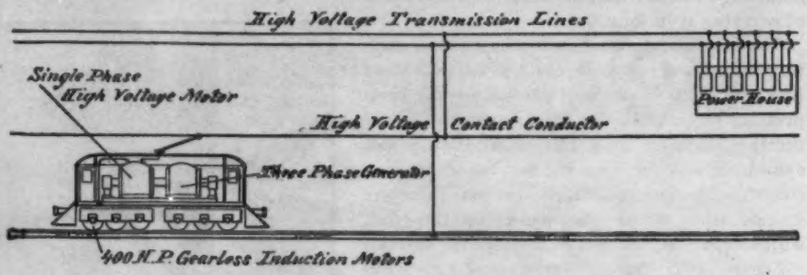


FIGURE 22. HALLBERG SINGLE-PHASE TO POLYPHASE SYSTEM.

At Spokane, Wash., is located one of the oldest water power systems on the coast. A waterfall on the Spokane River in the

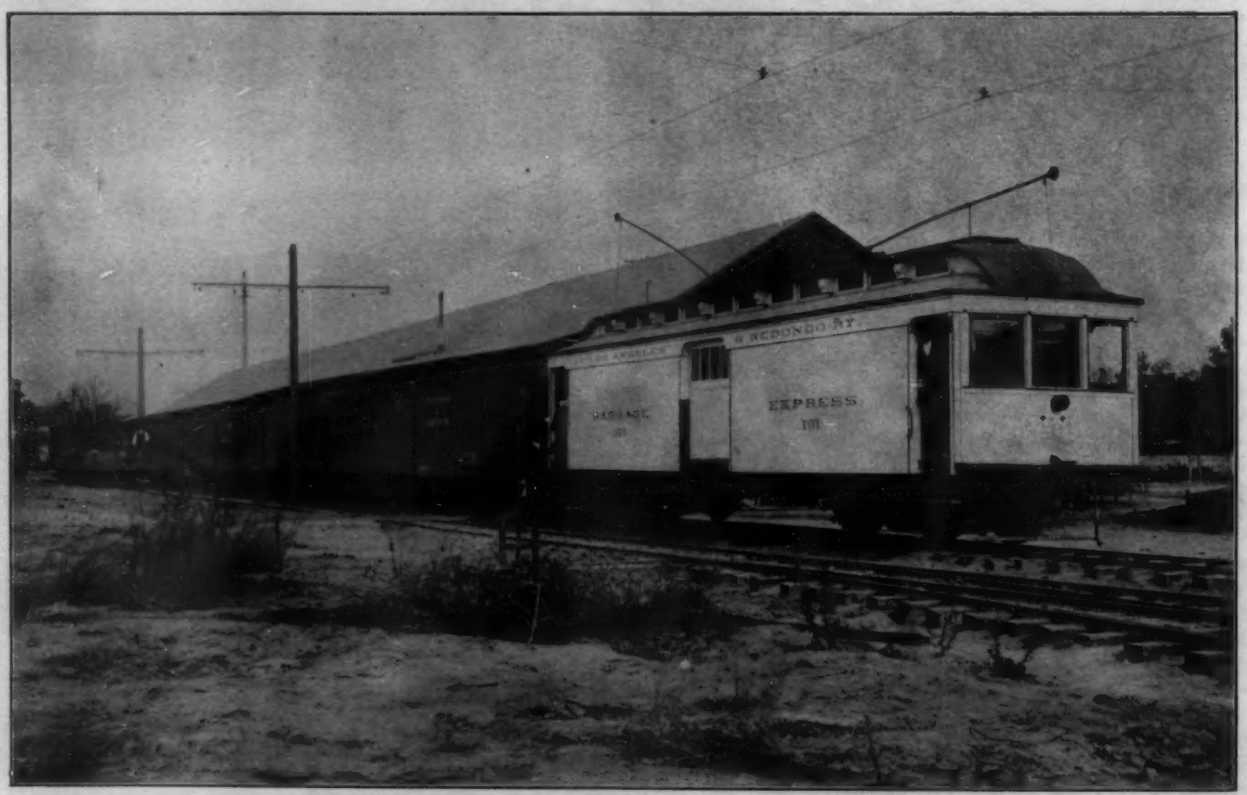


FIGURE 23. ELECTRIC FREIGHT LOCOMOTIVE, LOS ANGELES AND REDONDO RAILWAY

center of the city is utilized to develop 8000 horsepower. The power is used to operate all the electric railways in Spokane, as well as the modern passenger and freight interurban line between Spokane and Coeur d'Alene, Idaho. Some projected railways which will radiate from Spokane will also utilize this power. The Washington Water Power Company, which owns the hydro-electric plant, operates a 60,000-volt transmission line to the mining districts in Idaho, over 100 miles distant.

At Walla Walla a new water power plant is just being completed on the Walla Walla River, and its power will be utilized for projected railways in Walla Walla and vicinity. Similarly, on Rock Creek, in eastern Oregon, a 1500-horsepower hydro-electric plant is available for electric railway operation in Baker City.

Coming down to Portland, Or., we find practically an absolute dependence upon water power for the operation of over 200 miles of railway. This mileage includes the two city systems, which have recently been consolidated, as well as the extensive and modern interurban system of the Oregon Water Power and Railway Company (see THE JOURNAL for January, 1904) which connects Portland with Oregon City and Cazadero, the latter point thirty-eight miles from Portland. This power is generated at Oregon City, on the Willamette River, by the Portland General Electric Company, and is distributed through several substations. A new plant now being constructed by the Oregon Water Power and Railway Company, at Cazadero, on the Clackamas River, will soon be available for the generation and transmission of 10,000 horsepower, with an ultimate capacity of 25,000 horsepower. Railways projected from Portland towards Salem, on the south, Mt. Hood, on the east, and Hillsboro, on the west, will also utilize power from hydro-electric plants.

Before turning to a consideration of California systems, it is interesting to note the extensive hydro-electric transmission system in Utah, which is utilized to operate the electric railways of Ogden and Salt Lake City, as well as to supply lighting and power to various consumers. Some of the best pioneer hydro-electric work was carried on in Utah, and there the successful operation of several water power and steam plants in parallel was first successfully accomplished.

We will now consider for a moment what has been accomplished in electric traction in California, particularly with reference to lines which have operating conditions similar to those of steam railroads. The greatest amount of electric railway construction has been carried on in the vicinity of Los Angeles, where a network of interurban roads aggregating over 500 miles in length is successfully operated. There are three interurban railroad systems radiating from Los Angeles, viz: The Pacific Electric Railway Company's and the Interurban Railway Company's systems controlled by Henry E. Huntington; the Los Angeles-Pacific Railroad Company operating between Los Angeles and the ocean on the west, and the Los Angeles and Redondo Railway. The last named is the shortest, but is characterized by some very interesting features by reason of its handling freight trains and operating under steam road conditions. Figure 23 shows an electric locomotive with train of freight cars, the picture being taken at the Los Angeles terminal. Trains of this and even greater length are handled daily.

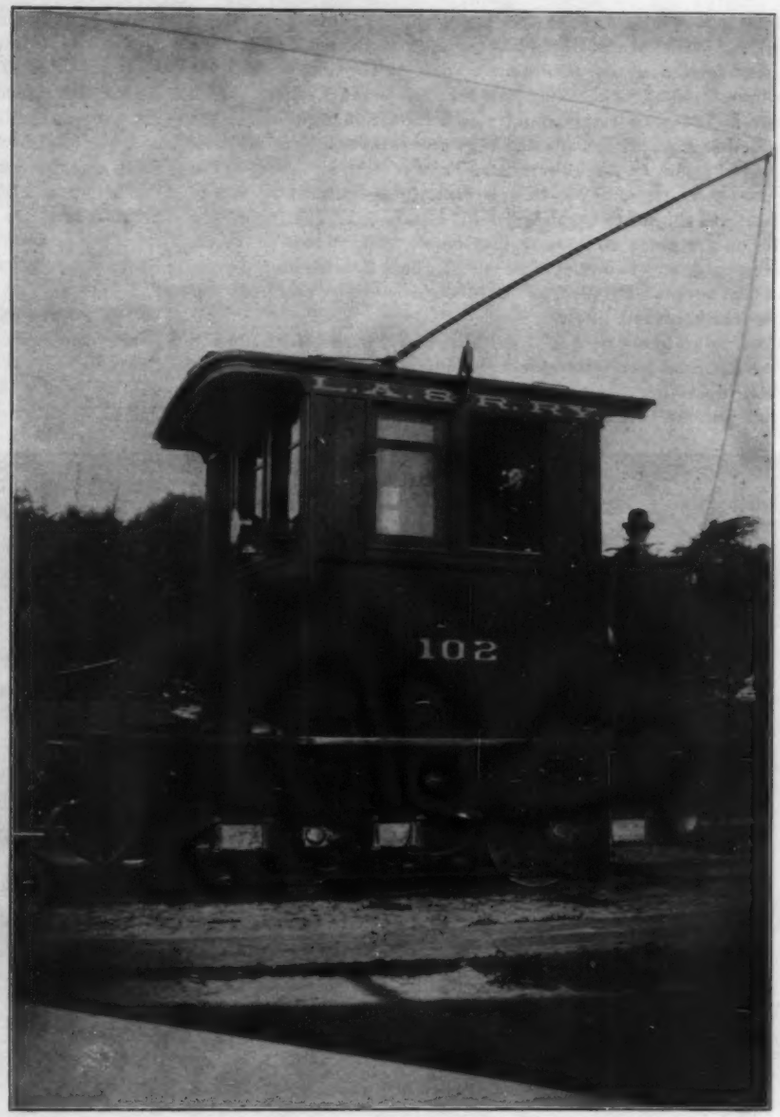


FIGURE 24. ELECTRIC SWITCHING LOCOMOTIVE, LOS ANGELES AND REDONDO RAILWAY

The Los Angeles and Redondo Railway owns the three wharves in Redondo, and all the lumber and other freight unloaded at this point is handled by means of electric locomotives. At the docks electric hoists are installed by means of which the lumber is discharged from the vessels onto the cars quickly and economically.

Figure 24 shows a small electric locomotive which was designed and built in the company's shops, at Redondo, and which does very efficient service in switching cars at and hauling whole trains from the docks to the steam road.

A feature of the operation of the Los Angeles and Redondo Railway which is of special interest in connection with the subject which we are discussing, is that the electric power used is all purchased from the Pacific Railway Company of Los Angeles. As this latter company is now receiving power from a plant on the Kern River, some 125 miles distant, it serves to illustrate the possibilities of hydro-electric power generation, transmission and distribution for the operation of railroads. The principal substation on the Los Angeles and Redondo Railway is illustrated in Figure 25. It receives electric power transmitted 140 miles and supplies power for the operation of the railroad and the electric hoists on the docks. It also furnishes current for lighting the city and for other power purposes.

Figure 26 is of interest as illustrating the transmission of high tension current for the electrical operation of railroads. The view shows a section of the Monrovia branch of the Pacific Electric Railway Company where it passes through orange groves. This track is laid with sixty-pound standard-section steel rails, the roadbed being heavily ballasted with gravel according to the most approved steam road requirements. The center poles carry at the top two three-phase 15,000-volt circuits which transmit power to substations similar to that shown in Figure 25. The remaining wires on the poles consist of two heavy copper trolley wires, feeder, cable and two telephone wires. This construction is the standard adopted by the Pacific Electric Railway Company for all of its interurban lines.

Coming up to our own section of the State, we find in the North Shore Railroad a very interesting example of the possibilities of electric operation on steam lines. As is well known, the section of this railroad between Sausalito and San Rafael has been operated for about a year and a half by electric power. This service has been carried on successfully, conjointly with steam operation, which is still depended on for the long distance travel to Cazadero.

Here the multiple-unit system is employed, and a standard train of cars is illustrated in Figure 27. Electric current is conveyed to the train by means of a third-rail, which at stations and terminals is protected by means of a hood or platform covering.

Figure 28 is a view at the north portal of the tunnel near Corte Madera. (Note the semaphore signals at each side of the track.) These are of the latest pattern designed by the Union Switch and Signal Company, and the system is the first to be installed in the country which utilizes alternating current in the track rail. The successful operation of this block signalling system on the North Shore Railroad led to its adoption for the entire New York subway system. The illustration also shows the aluminium cables which carry power to the electric supply rail, and which at this point are carried over the hill and join the track again at the other end of the tunnel.

The power house from which the North Shore Railroad is operated is situated at Alto, a point about midway between San Rafael and Sausalito. This station is of especial interest on account of its being designed to receive three-phase current at 60,000 volts from the transmission lines of the Bay Counties Power Company, and because of the installation of a modern steam plant for reserve and auxiliary purposes. It is also interesting to note that the Alto power house is the terminus of one of the longest transmission lines on the Bay Counties System, it being 180 miles from the power house at Colgate and 230 miles from the new de Sabla power house.

Figure 29 is an interior view of the generator room, showing two motor-generator sets, which normally are driven by the alternating three-phase current, supplying 600-volt direct current to the railway feeders. As may be noted, connection is also made so that these motor-generator sets may be driven through a rope drive from a steam engine.

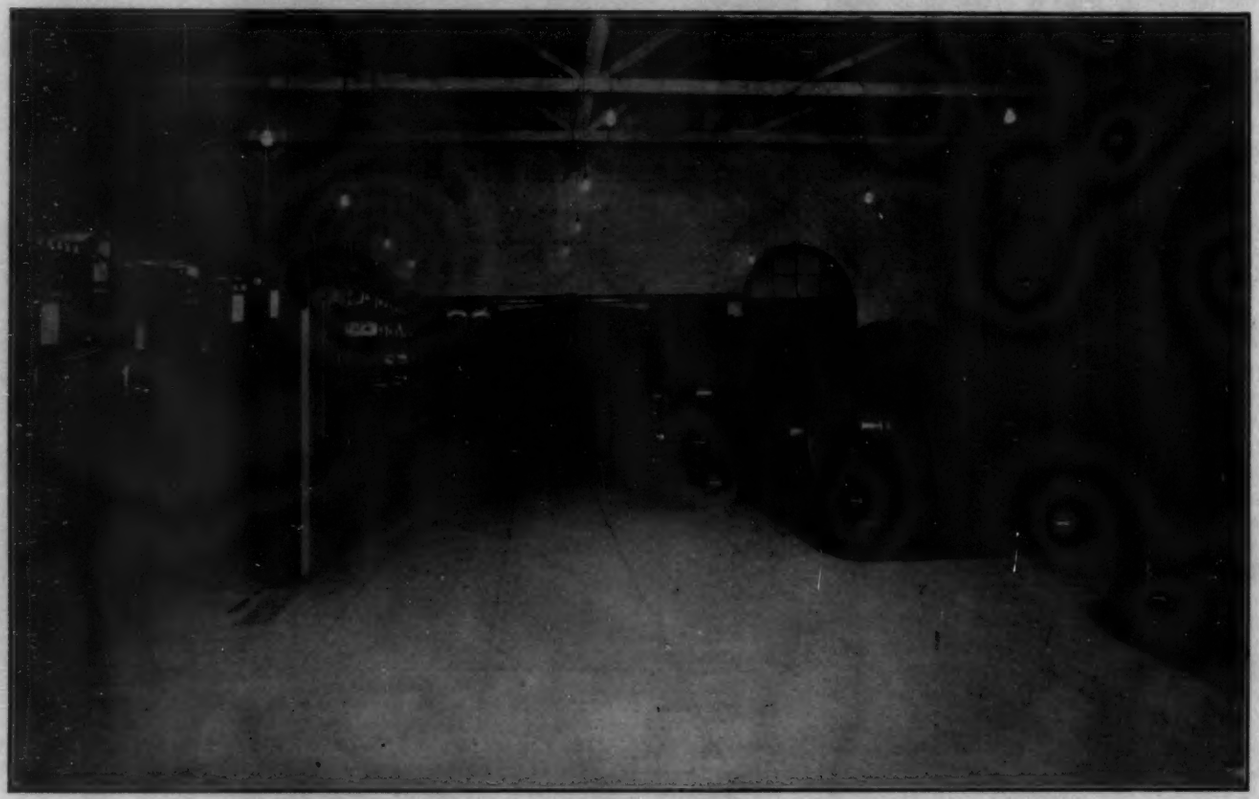


FIGURE 25. SUBSTATION AND MOTOR-GENERATOR SETS, LOS ANGELES AND REDONDO RAILWAY

The electric railway system operated by the San Francisco, Oakland and San Jose Railway Company, popularly known as the "Key Route" possesses very striking and interesting features, some of which have attracted attention throughout the entire country. This line, as is well known, was built to give a rapid and frequent service in connection with fast ferry boats between San Francisco and Berkeley and Oakland. That it succeeded is evidenced by the crowds of people who daily ride on its trains and also by the fact that the object lesson of its splendid service seems destined to cause the older suburban system to be electrified. The general features of the Key Route are too well known to require detailed explanation, but a few of its features of construction are worthy of special note.

Figure 30 is a view of the pier, showing two of the standard four-car trains. As in the case of the North Shore Railroad, these are operated by the multiple-unit system which possesses many advantageous points for a service of this kind. The regular lengths of trains during the day are three and four cars, but at night and morning seven and eight-car trains are regularly

handled, and on special occasions nine and ten cars have been successfully operated in one train.

Figures 31 and 32 are views at the terminal train shed on the pier. (Note the clean unobstructed building.) It is needless to say that the absence of smoke in stations is a great advantage from the point of cleanliness, comfort and health.

A novel and, in some respects the most important, new feature on the Key Route is the diamond shaped trolley which is used to collect current from the overhead conductors. It was designed by J. Q. Brown, assistant general manager of the road, after one of the large Eastern manufacturing companies had stated point blank that it was unable to furnish a suitable collector for the heavy Key Route trains. The details of the construction of the trolley were worked out by the late George Spink and George St. Pierre, the present master mechanic of the railroad.

Figure 33 shows this trolley raised to its extreme height and Figure 34 shows it lowered. The extreme play, namely, from eighteen inches to eighty-four inches above the car roof was necessitated by reason of the low head room in the subway under the Southern Pacific tracks and no account of the high trolley wire in Berkeley. The trolley frame adjusts itself automatically to the height of the trolley conductor and required absolutely no attention from the train crew. The contact is made by a brass roller thirty inches in length and five inches in diameter which is mounted on a steel shaft and supported on special bearings at the ends. The wearing qualities of this trolley are such that if a roller should be kept in continuous operation it would not wear through or need to be replaced in less than nine months. As a matter of fact the rollers are taken out and replaced frequently on account of the wear in the bearings. This, however, is only a mechanical feature, and is readily attended to at the end of the days run. The operation of the trolley from an electrical standpoint has been very successful, even exceeding the expectations of the inventor. During a test nearly a thousand amperes has been taken from a trolley wire through a single roller. This seems incredible when it is realized that the roller with a diameter of five inches and the trolley wire with a diameter of about half an inch must necessarily afford a very small contact. In regular operation two trolleys are used for a four-car train and three for a seven-car train. There are evidently great possibilities for such a type of current collector in the operation of heavy trains requiring the taking of considerable power from an overhead conductor.

At the present time there are several electric traction projects undergoing careful investigation on the Pacific Coast, and others seem to be formulating. The Southern Pacific Company has for some time been making an exhaustive study of the electrical systems now on the market with a view to electrifying all of its suburban lines in Oakland, Berkeley and Alameda. This improvement will involve a heavy expenditure, but one which is fully warranted by the conditions. There has also been some talk of the Southern Pacific Company electrifying its steam line between San Francisco and San Jose. When the electric interurbans now operating and projecting between these two cities are completed, the steam railroad probably will follow the example of its competitors. Undoubtedly electric traction between this city and the center of the Santa Clara Valley is not far distant. Another important line which is said to have been carefully considered for electrical operation is that between Oakland and Port Costa, where, even in the present state of the art, the heavy and frequent service would seem to make a change profitable.

Improvements in construction and efficiency will hasten the development of electric systems, and it is safe to predict that the trunk railroads of the State will at no remote day be adapted to electrical operation. Perhaps one of the first changes to be made in that direction will be the conversion of the mountain divisions. Announcement has already been made that the Southern Pacific Company has considered the feasibility of operating its line between Sacramento and Truckee by means of electric locomotives, obtaining the power from a hydro-electric plant on the Truckee River. The introduction of electric locomotives on some such portion of an old established steam railroad will be but the forerunner of many similar improvements, and eventually will lead to the electrification of all of the railroads. As has been men-

FIGURE 28. HIGH VOLTAGE TRANSMISSION LINE AND TROLLEY CONSTRUCTION, PACIFIC ELECTRIC RAILWAY

FIGURE 27. NORTH SHORE ELECTRIC TRAIN

FIGURE 28. NORTH SHORE ELECTRIC TRACK AT CORTE MADERA TUNNEL

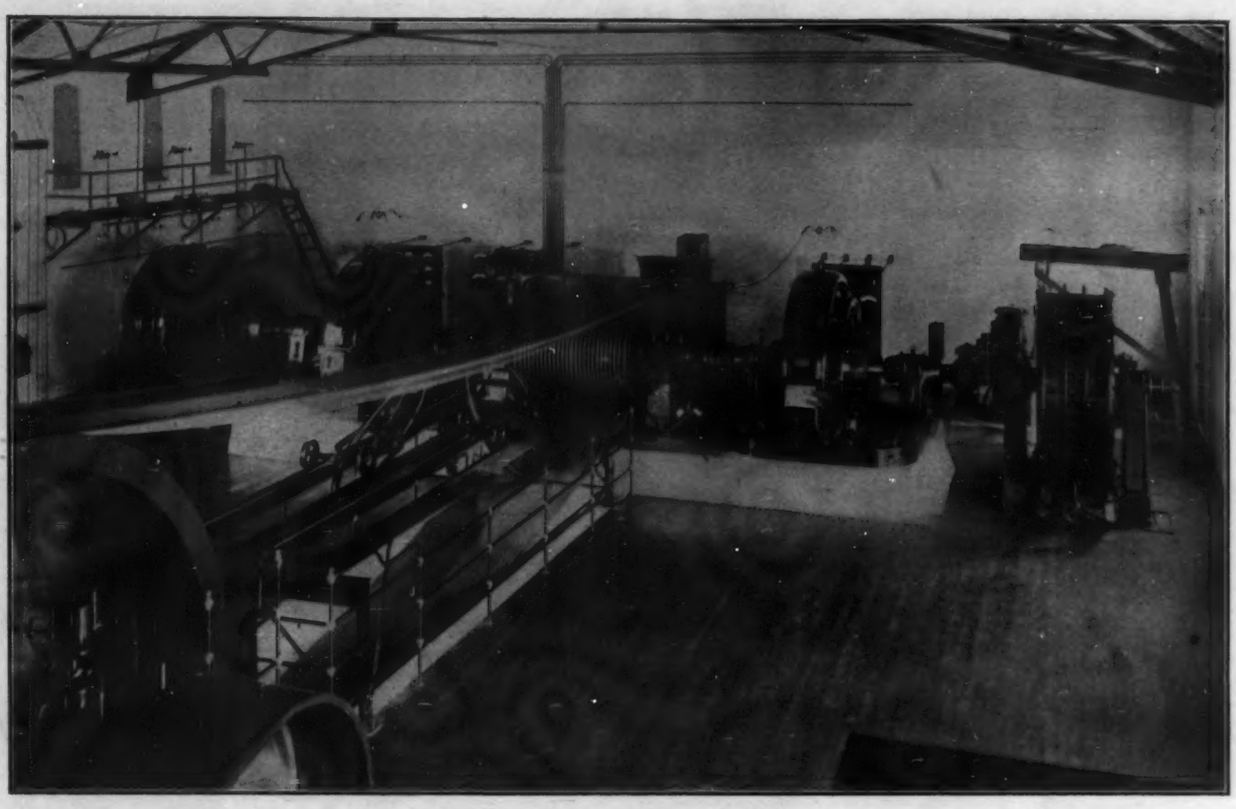


FIGURE 29. NORTH SHORE SUBSTATION AND POWER HOUSE

FIGURE 30. KEY ROUTE PIER, SHOWING TWO STANDARD TRAINS

FIGURE 31. KEY ROUTE TERMINAL TRAIN SHED

FIGURE 32. KEY ROUTE TERMINAL TRAIN SHED

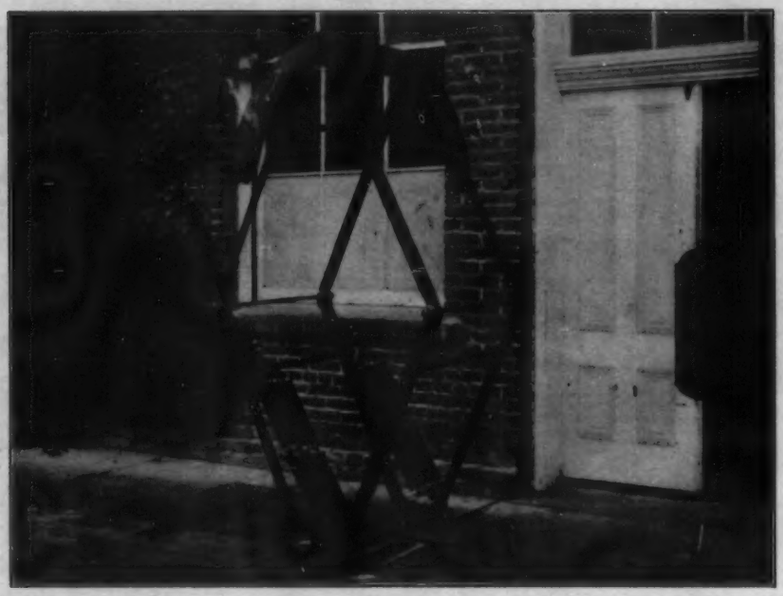


FIGURE 33. KEY ROUTE TROLLEY, RAISED

tioned before, California and the other Pacific Coast states seem to be particularly adapted to the electrification of the railroads by reason of the large water powers available and already partially developed.

As further indicative of the increasing utilization for the operation of railways of electric current generated at and transmitted from water power plants, we note the street railway systems of San Francisco, Oakland, San Jose, Sacramento, Stockton and Bakersfield. The San Francisco system, the ninth in size in the United States, before another year has past, will be operated by power furnished by the California Gas and Electric Corporation from its many water power plants. As a reserve and for special use during peak loads, a gas engine central station is being installed in San Mateo County just south of the city. This station will be a model of its kind and will contain three 4000-kilowatt revolving-field alternators directly driven by gas engines, the largest ever constructed.

The system of the Oakland Traction Consolidated, embracing all the street railways in Oakland, Berkeley and Alameda, as well as the interurban road to Haywards, has been operated for several years by power furnished by the California Gas and Electric Corporation from its water power plants.

San Jose is rapidly becoming a center for an extensive railway system that will tap all the productive, as well as the scenic, sections of the beautiful Santa Clara Valley. Interurban lines are already operating to Santa Clara, Alum Rock, Saratoga and Los Gatos, while lines are projected to Palo Alto and thence to San Mateo to connect with the United Railroad's line; to Mt. Hamilton, to Berryessa and other points. The lines now built are operated from a substation of the Standard electric transmission system, and this same power will no doubt be utilized for the new lines.

At Sacramento we similarly find an extensive railway system operated by hydro-electric power, and it is interesting to note in this connection that power from the Folsom plant on the American River was transmitted to Sacramento and used to operate electric railways in 1895—the first utilization of water-generated power for railway operation in the State.

At Stockton and at Bakersfield the electric railways are also operated by hydro-electric power, it being largely depended upon for lighting and power purposes in both cities.

Among projected lines which undoubtely will be dependent upon hydraulically generated power for their operation may be mentioned the Oakland and Marysville Railway, which it is said is to be built from Oakland through Sacramento to Marysville; the railway projected from Marysville east to Downieville; an extensive local and suburban system at Chico, with interurban lines to Colusa, St. Johns and Oroville; the Yosemite Valley line, and the new system now being built from Ione to Jackson and Sutter Creek.

Realizing the great agricultural development which is in store for the Sacramento and the San Joaquin valleys, it is well within reason to predict an electric railway trunk system there. This line will probably be constructed through the fruit belt east of the present steam railroads, and could thus be very conveniently operated from the vast water powers available along the westerly slope of the Sierra Nevada Mountains. Such a system would have numerous feeders reaching into the many fertile valleys among the foothills and also have terminals at Sacramento, Stockton and on San Francisco Bay.

Many interesting hydro-electric power plants and transmissions have been built in California and are in successful operation.

California engineers have led the world in the development of water power utilizing the highest heads, and in transmitting electric power to the greatest distances at the highest voltages.

This industry has had a wonderful growth in recent years and its developement was made possible by the tangential water wheel, which was devised by the early-day miners of California to utilize the high heads and comparatively small amounts of water available.

The plants now in operation were built where the greatest power could be developed with the least expenditure of money, and they are located at intervals all the way from Los Angeles to Mt. Shasta, as shown by the sketch map, Figure 35. Although the undeveloped water powers of the State which can be made avail-

FIGURE 34. KEY ROUTE TROLLEY, LOWERED

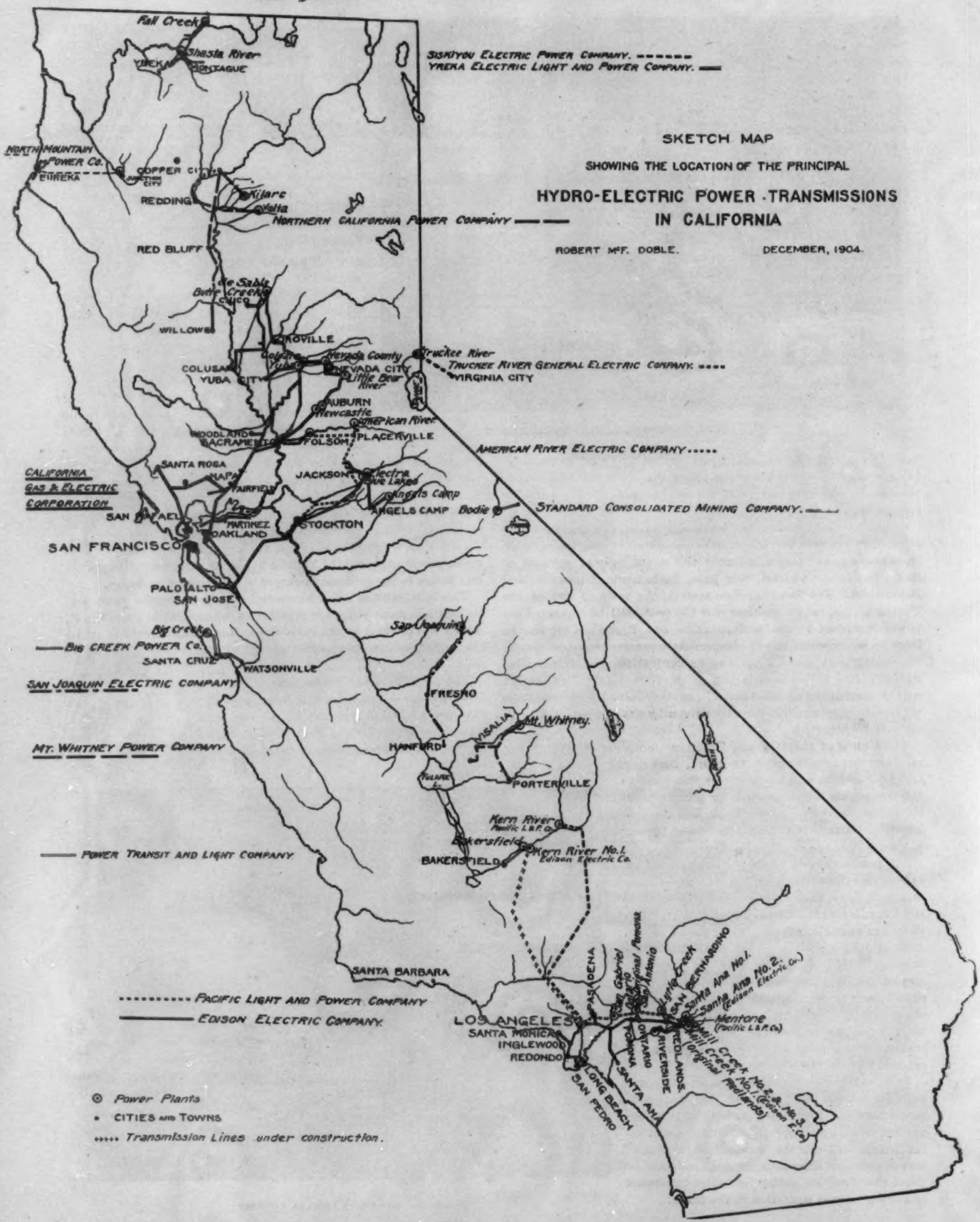


FIGURE 35. MAP OF HYDRO-ELECTRIC POWER PLANTS AND TRANSMISSION SYSTEMS IN CALIFORNIA

able for commercial transmission of electric power far exceed in energy all the powers now utilized, an inspection of the map (Figure 35) and a study of the diagram (Figure 36) which gives the hydraulic head, transmission voltage and transmission distance of the principal plants in California, make it apparent that much has already been done.

Space does not permit of a description of all of the plants, each of which has its interesting and characteristic features, so a brief description will be given of a few of the more important ones.

One of the most widely known plants on the Pacific Coast is the Colgate plant, an interior view of the power house being shown in Figure 37. It is built on the North Yuba River, and contains six generating units having a total capacity of more than 12,000 horsepower and utilizes an effective head of water of more than 700 feet. The transmission line extends 140 miles to Oakland.

The electric power house, the interior of which is shown in Figure 38, was built by the Standard Electric Company on the Mokelumne River. The transmission line extends to Oakland, and thence via San Jose to San Francisco, a distance of 154 miles.

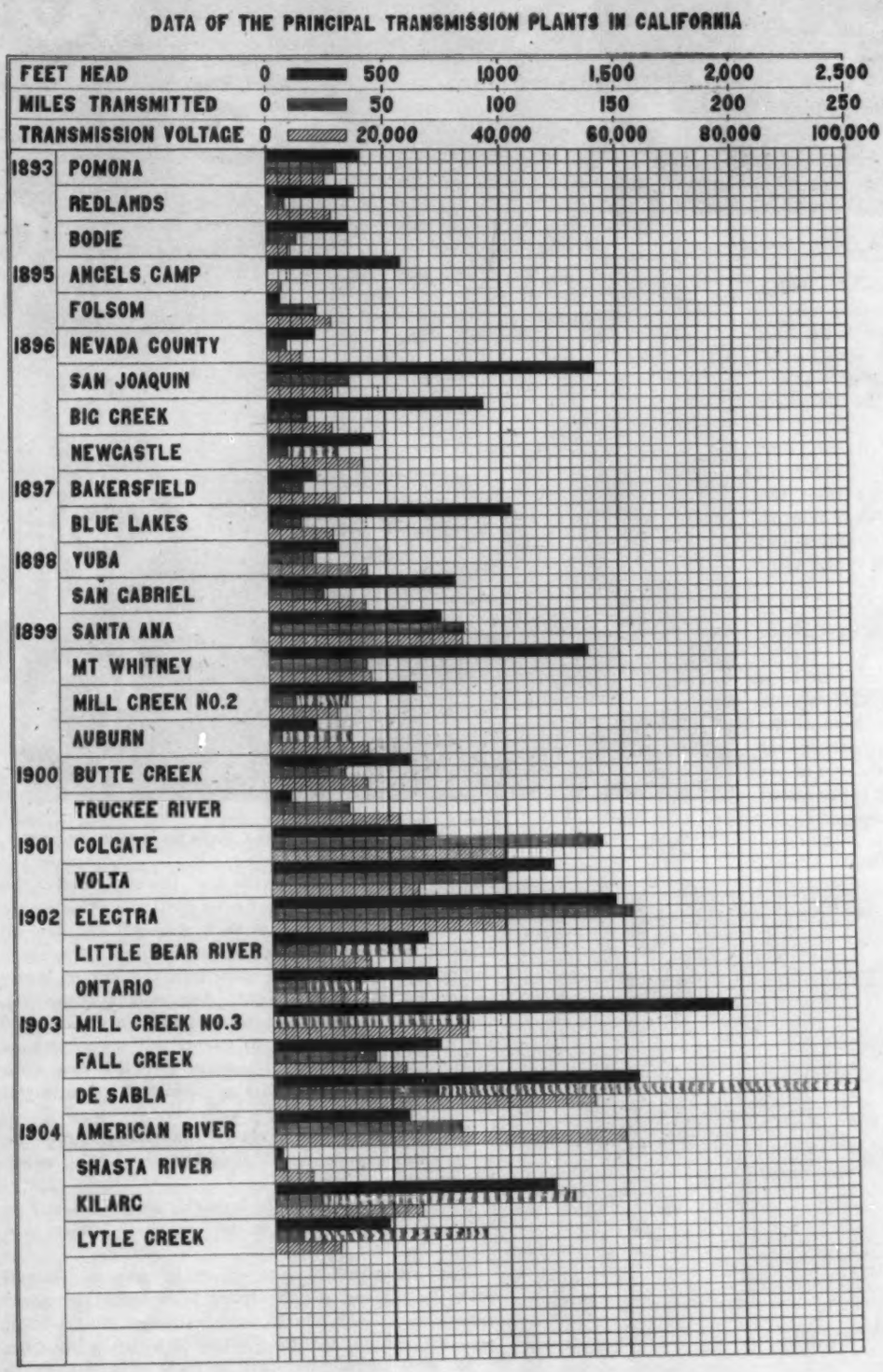


FIGURE 36. DATA OF THE PRINCIPAL TRANSMISSION PLANTS IN CALIFORNIA

The power house contains five 2000-kilowatt generators driven by tangential water wheels operating under an effective head of more than 1400 feet.

One of the tangential water wheels operating in the Mill Creek No. 3 power house of the Edison Electric Company of Los Angeles under an effective head or more than 1900 feet is shown in Figure 39. Each of these water wheels drives a 750-kilowatt generator. This plant has been in operation since 1903, and has proven successful in every way.

In order to obtain the highest efficiency from the water used, it is necessary that the stream projected from the nozzle at the lower end of the pipe line, against the water wheel buckets, should be of perfect form and solid. A flashlight photograph of such a stream as is used at the Mill Creek No. 3 and the de Sabla plants is shown in Figure 40.

The de Sabla plant, located on Butte Creek, one of the most recently completed installations, is a striking example of Western power development and embodies the most advanced ideas in power plant engineering.

The power house contains three two-bearing type hydro-electric generating units, two of 2000 kilowatts and one of 5000 kilowatts normal capacity.

The water for operating the plant is conveyed from the river through a ditch and discharged into a regulating reservoir which is at an elevation of 1560 feet above the power house. This reservoir is tapped directly by two thirty-inch steel pressure pipe lines, about 6000 feet in length, which conduct the water to the power house, where the water pressure at the nozzle is more than 675 pounds per square inch.

The 5000-kilowatt unit has been recently installed, and is

FIGURE 37. INTERIOR OF COLGATE POWER HOUSE

remarkable because of the high speed at which it revolves, namely 400 revolutions per minute, and from the fact that it is driven by the most powerful single water wheel yet constructed. An outline drawing is shown in Figure 41 and a photograph of it, as installed in the power house, is shown in Figure 42.

The water wheel is capable of delivering 8000 horsepower from the single jet of water, six inches in diameter, which issues from the needle regulating deflecting nozzle at a velocity of approximately 20,000 feet per minute and impinges upon the steel buckets of the water wheel.

From the power house, the transmission line conveys the current fifty miles to the Colgate power house.

Electric power from this plant has been delivered in Calaveras County, via Colgate, Oakland and Stockton, over the lines of the California Gas and Electric Corporation and the Standard Electric System, a distance of 345 miles from the power house, which is the record at present of long distance transmissions.

NOTE—Indebtedness is acknowledged to the *Electrical World and Engineer* for the diagrams Figures 18, 21, 22.

FIGURE 38. INTERIOR OF ELECTRA POWER HOUSE

SOME HINTS ABOUT TRANSFORMER OIL.*

BY C. E. SKINNER.

BEFORE filling the case of a transformer with oil, precautions should be taken to see that there is no water in the case and that the transformer itself is dry. It sometimes happens that during the shipment of transformers they are exposed to the weather and that after unpacking it is necessary to transport them for some distance in wagons without covers, giving a chance to collect moisture. Every possible precaution should be taken to prevent moisture entering the cases before they are filled with oil, and care should be taken to remove all air bubbles which may find lodgement in the coils or insulation of the transformer.

It sometimes happens that through faulty bushings or lack of proper precautions in closing up the case when the transformer is installed, water will find its way into the case. This always settles to the bottom of the case, and when in sufficient quantities will rise so as to reach the coils and cause a burn-out. In high-tension transformers the presence of water in the oil is dangerous and may cause burn-outs even though the water does not reach the transformer windings. If water is suspected it may be readily found by inserting a thin glass tube down the side of the transformer to the bottom of the case, the upper end of the tube being stopped by the finger until the tube strikes the bottom. The finger is then removed and the oil allowed to enter the lower end of the tube. The upper end is then closed and the water from the bottom, if any be present, may be drawn out. The contents of the tube should than be discharged into a tall bottle or test tube and if water is present in any quantity it should at once be apparent to the eye. The remedy in this case is to remove the oil from the transformer and substitute oil which is known to be free from water.

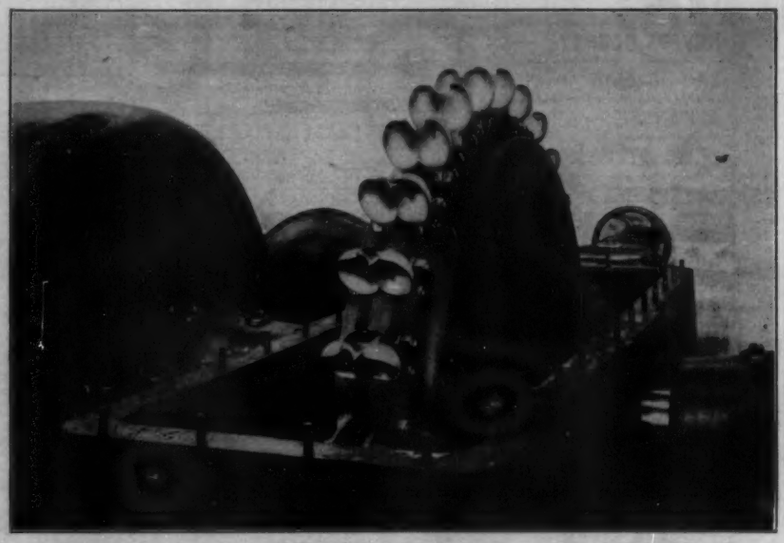


FIGURE 39. DOBLE TANGENTIAL ELLIPSOIDAL WATER WHEEL IN MILL CREEK NO. 3 POWER HOUSE

For the purpose of a clearer understanding of the subject we may define water and moisture in oil as follows:

Water is that portion which readily settles out and so becomes at once apparent to the eye when placed in a glass vessel.

Moisture is that portion which is intimately mixed with the oil and which cannot be detected by visual examination. Oil which contains water must also of necessity contain moisture, while oil which is free from water may contain moisture to such an extent as to seriously impair its insulating property.

The Electric Club Journal, Volume II, page 96, February, 1905.

FIGURE 40. FLASHLIGHT PHOTOGRAPH OF JET PROJECTED BY DOBLE NEEDLE REGULATING NOZZLE

eight-inch vacuum being approximately 40 degrees C. This lowering of the boiling point makes efficient drying possible at a lower temperature than when the drying is done at atmospheric pressure and consequently with less risk of overheating the insulation during the drying process. For this operation it is of course necessary to provide a vessel for containing the transformer, preferably its own case, which can be made vacuum tight. The air is then exhausted and the transformer heated to a temperature sufficient to drive out the moisture. The oil can be heated in a separate tank in the same way and at the same time if proper arrangements are made. This drying out should be continued until the insulation resistance of the transformer shows it to be completely dry and the oil shows a very high dielectric test. The transformer case should then be filled with oil while the vacuum is maintained, the oil being introduced at the bottom at a moderate rate. This will result in the transformer case being completely filled, absolutely eliminating moisture and air bubbles.

Oil which contains water is not injured for use provided the water is removed. This may be done by allowing the water to settle at the bottom, drawing off all this water, and then drying out the moisture contained in the oil by heating it to a temperature of 100 to 110 degrees C. until a test of the oil shows no moisture present.

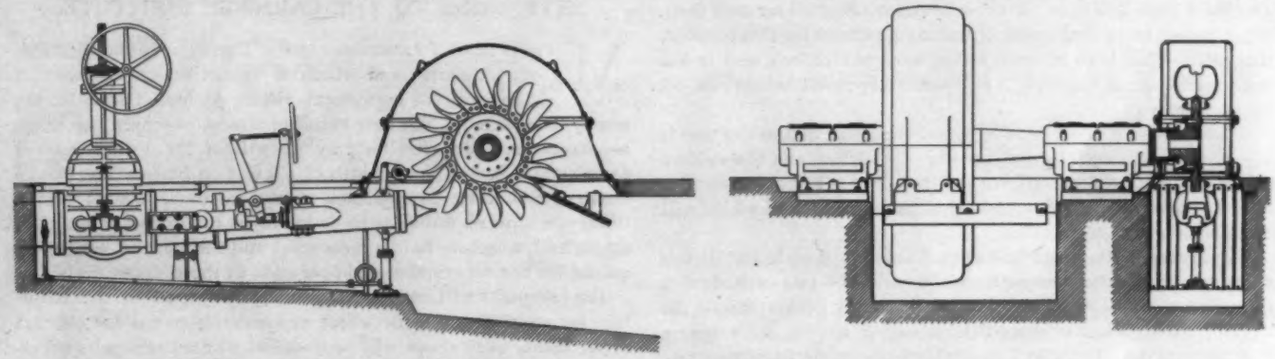


FIGURE 41. OUTLINE DRAWING OF DE SABLA 8000-KILOWATT DOBLE-STANLEY HYDRO-ELECTRIC GENERATING UNIT

Every possible precaution should be taken to see that the cooling coils of water-cooled transformers are tight, but it may happen that during shipment or handling or from other causes the cooling coils are damaged and become leaky. Water, of course, then enters the oil and settles to the bottom. If such transformers are not provided with a gauge glass at the bottom for the observation of water, some of the oil should be drawn from the bottom of the case occasionally and tested for water. The entering ends of cooling coils, which are not covered with oil, should be lagged with tape or some other heat-insulating material to prevent the condensation of moisture on the cold coils in the presence of the warmer air from the heated transformer. This lagging should be kept in good condition.

The foregoing remarks as to precautions to be observed apply to low and medium high tension transformers. With transformers having higher voltages, additional precautions are necessary, particularly in regard to the drying out of the transformer and the oil. A slight amount of moisture in the oil used in a low tension transformer may not cause any trouble whatever, while the same amount in a very high tension transformer would prove disastrous. The best possible results are obtained by drying the transformer, and sometimes the oil, in a vacuum.

The boiling point of water is greatly reduced as the vacuum is increased, the boiling point under a twenty-

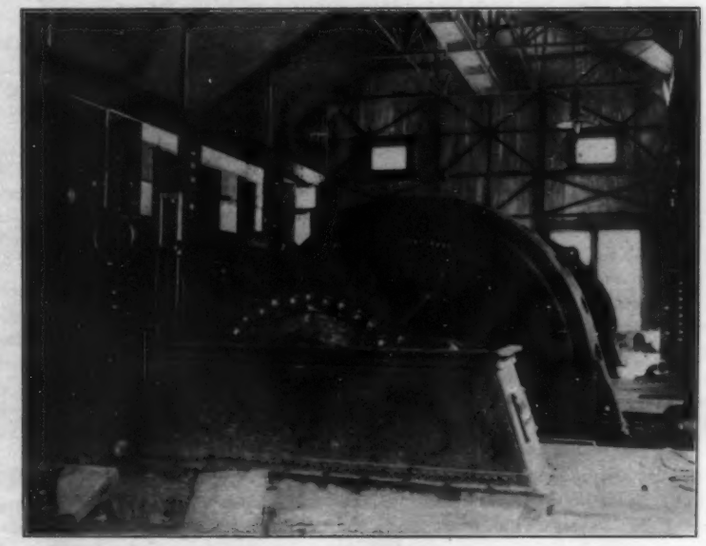


FIGURE 42. THE DE SABLA 8000 HORSEPOWER DOBLE-STANLEY HYDRO-ELECTRIC GENERATING UNIT

A very satisfactory test may be made by placing a small amount of the oil in a cup and plunging into it a piece of iron which is heated to a temperature slightly below a dull red heat. Any hissing or crackling noise indicates the presence of moisture. The dielectric test affords a far more satisfactory indication. This test is made by means of a high potential transformer and a testing cup consisting of a 200-cubic centimeter graduated glass vessel, one and three-eighths inches inside diameter, with a hole drilled through the bottom, through which the lower terminal is inserted. The testing terminals consist of two brass balls, one-half-inch in diameter, fastened to three-sixteenths-inch rods. The upper rod passes through a clamp, which is connected to a micrometer screw actuated by a milled head. The lower terminal should fit in a socket so that it may be readily removed for cleaning. The bottom of the cup is made oil tight by the use of gaskets where the lower rod passes through the cup. An extension of the lower rod comes in contact with a spring set in the base of the stand to which the line terminal is connected by means of a convenient binding post. Stops are provided so that the oil vessel may always be placed in the same position. The rod may slide up and down easily when the clamping screw is free, or may be engaged with the micrometer screw at any point for closely adjusting the gap. All parts are therefore readily accessible for cleaning, and the zero point of the gap may be quickly adjusted for each test by allowing the upper rod to slide down, so that the terminals are in contact, and then clamping to the micrometer screw. The apparatus is always filled to the 200 cubic centimeter mark (requiring a little less than 200 cubic centimeters of oil for each test). After trying numerous forms of testing apparatus for this purpose, this method has been adopted as the most convenient, and it has the advangtage of requiring a comparatively small amount of oil for each test.

When a sample of oil is to be tested the spark gap in the cup is adjusted to a convenient size, usually 0.15 inches, and the voltage raised gradually till breakdown occurs. Dry oil should stand a test of at least 20,000 volts, and oil is frequently found which will stand 25,000 to 33,000 volts.

It occasionally happens that a small amount of scale and dirt is found in the oil, this coming from the inside of the cask during shipment. All oil which is shipped in metal drums should be strained through two or three thicknesses of cheese cloth before it is put into use. This will insure that the oil is free from any foreign matter which might be detrimental to the transformer.

In taking samples of oil for tests it is customary to use what is known as a "sneak" or "thief." This instrument consists of a tube approximately one inch in diameter with both ends reduced so as to have small apertures. This is introduced into the oil to be sampled, the upper end being kept stopped with the finger until the lower end of the sneak reaches the bottom of the oil. The finger is then removed, the oil from the bottom fills the tube, which is then drawn out by replacing the finger on the upper end of the tube, when the oil may be discharged into a sample bottle. This method of sampling insures that any water or dirt in the oil, which naturally settles to the bottom, will be taken with the sample.

ONE OPERATOR SENDS OVER THE WHOLE COUNTRY.

RECENTLY the Associated Press had its circuits running east from San Francisco so extended that they covered almost the entire United States, all successfully worked by the San Francisco operator. Ordinarily San Francisco works direct with Salt Lake City, but on the morning in question Salt Lake City, through the use of automatic repeaters, connected the San Francisco circuit not only to the north, through Montana, but to Denver and Kansas City as well. San Francisco had also put San Diego, Fresno and Los Angeles on, thus sending east and south simultaneously. Denver, not to be outdone, attached the Colorado Springs-Pueblo-Leadville circuit, while Kansas City, by the similar use of repeaters, connected St. Joseph, St. Louis and Chicago. While the circuit as thus constituted is not infrequently made use of during the early hours of the morning, when the wires of the great news-gathering association are kept open for the transmission of bulletins and important foreign news, the limit was reached when the Chicago operator, seeing that he obtained San Francisco as clearly as though the transmitting were being done from the Union stock yards, put his first New York circuit on.

On this particular circuit are to be found the leading Eastern cities, such as Pittsburg, Philadelphia, Washington and Cleveland. Chicago then connected his Southern circuit, which runs by the way of Indianapolis and Cincinnati to Louisville. Louisville heard San Francisco's writing very distinctly, and connected the cities to which he ordinarily relates matter, that is, Memphis, Nashville and New Orleans. Memphis, in turn, put Dallas and Little Rock through on repeaters.

San Francisco started out at a fairly rapid rate, transmitted a long official report from General Nogi's headquarters. During its transmission only one "break" was recorded, when San Francisco transmitted for about two hours further without another break being made.

Telegraphers of long experience do not hesitate to say that this was undoubtedly the longest telegraph circuit ever maintained, considering the number of offices on the circuit by which the matter was copied. Because of the dearth of business at such an hour, the circuit was unusually free from induction—an element most important in its formation.

EXTENSIONS TO THE CARNEGIE INSTITUTE.

MAGNIFICENT extensions to the Carnegie Institute Building, Pittsburg, and which represent an expenditure of $5,000,000, the munificent gift of Andrew Carnegie, are nearly completed. The new building almost obscures the original structure, which itself a previous gift of Mr. Carnegie, cost $3,000,000. It occupies a width of 400 feet on Forbes Street and a depth of 600 feet. In addition to the portion devoted to the library, within its walls are to be found art galleries, a museum, a music hall, a lecture hall, a restaurant and the general offices required for the supervision and operation of these many divisions.

The basement will be an exceptionally busy part of the building, for aside from the modeling and casting rooms for the art department, work shops will be installed where the repairs necessary for the maintenance of the building will be carried out. The printing office and bindery used in connection with the library, and the large lighting and heating plant necessary for illuminating and warming such a vast structure, are also situated in the basement. The scheme of workmanship is based on a very high standard, the architects, Messrs. Alden & Harlow, having based their designs on the leading institutions of this type, both in Europe and this country.

The contract for the electric generators has been let to the National Electric Company, Milwaukee. It consists of five 300-kilowatt, 120-revolutions per minute, twelve-pole, 120-volt, direct current, engine type generators. These machines will be of the latest design and best material, of massive though pleasing appearance, the heaviness in outline being relieved by the elliptical section of the frame. All visible bolts will be nickle plated and the field coils taped on the outside and finished with a wrapping of fish net cord. The terminal boards will be of Vermont marble. The total net weight of each generator will be about 55,000 pounds, the armature and commutator accounting for 18,000 pounds. On the final test the generators will be expected to withstand a momentary overload of 75 per cent. without flashing, and to operate from no-load to 25 per cent. overlood without shifting the brushes.

Wynn Merdith, electrical engineer of the Engineering Offices, 331 Pine Street, has gone to Vancouver, B. C. He will spend about two months in the North in superintending the installation of the Britannia Copper Mining Company's new hydro-electric plant.

On the Economy of Steam Power Plants Using Oil Fuel—II.*

Continued from page 102 of The Journal for March, 1905.

TABLE NO. 4—POWER PLANT ECONOMY—POWER DRIVEN AUXILIARIES. EXPRESSED IN POUNDS TOTAL EVAPORATION FROM AND AT 212° IN BOILER, INCLUDING OIL BURNERS, PER POUND STEAM CONSUMPTION MAIN ENGINE.

CHAS. C. MOORE & CO., ENGINEERS (INC.). SAN FRANCISCO, CAL.

Steam Used in Pounds Per Indicated Horse-power-Hour			Cooling Water W × H	Horsepower in Pump Cylinders			Pounds Steam Per Hour Used by Pumps			Total Feed Water Pounds	Per Cent. Total Feed to Auxiliary Heater	Assumed Temperature of Hot Well	Temperature of Feed Water.	Factor of Evaporation	Total Evaporation From and at 212°	Total Evaporation From and at 212° +5 Per Cent.	Total Evaporation From and at 212° +10 Per Cent.	Horse-power Driven Auxiliaries Per Pound of Steam
Air	Circulating	Feed		Air	Circulating	Feed	Air	Circulating	Feed									
Case VII.			**Small Plants—Belted Air and Circulating Pumps; Direct Acting Feed Pumps.**															
....	....	200	500	.00018	.000253	.000194	....	....	.0485	1.1154	4.4	120	145	1.1187	1.248	1.310	1.373	.00094
Combined Efficiency.			1000	.00018	.000505	.000194	....	....	.0485	1.1154	4.4	120	145	1.1187	1.248	1.310	1.373	.00152
			1500	.00018	.000758	.000194	....	....	.0485	1.1154	4.4	120	145	1.1187	1.248	1.310	1.373	.00208
			2000	.00018	.001010	.000194	....	....	.0485	1.1154	4.4	120	145	1.1187	1.248	1.310	1.373	.00264
32½%	43¼%	80%	2500	.00018	.001263	.000194	....	....	.0485	1.1154	4.4	120	145	1.1187	1.248	1.310	1.373	.00302
Case VIII.			**Large Plants—Direct Connected Air Pumps; Engine Driven Centrifugal Circulating Pumps; Direct Acting Compound Feed Pumps.**															
....	40	100	500	.00018	.000253	.000194	....	.0184	.0242	1.1092	3.8	100	140	1.1238	1.247	1.309	1.372	.00037
Combined Efficiency.			1000	.00018	.000505	.000197	....	.0367	.0247	1.1291	5.4	100	147	1.1165	1.261	1.324	1.387	.00037
			1500	.00018	.000758	.000201	....	.0551	.0251	1.1491	7.0	100	172	1.0904	1.251	1.314	1.376	.00037
			2000	.00018	.001010	.000204	....	.0735	.0255	1.1692	8.5	100	187	1.0747	1.257	1.320	1.383	.00037
48¼%	55%	80%	2500	.00018	.001263	.000208	....	.0919	.0260	1.1892	9.9	100	200	1.0611	1.262	1.325	1.388	.00037
Case IX.			**Medium Plants—Motor Driven Air and Circulating Pumps; Direct Acting Feed Pumps.**															
....	....	150	500	.00018	.000253	.000193	....	....	.0362	1.1023	3.3	110	135	1.1290	1.244	1.306	1.368	.00114
Combined Efficiency.			1000	.00018	.000505	.000193	....	....	.0362	1.1023	3.3	110	135	1.1290	1.244	1.306	1.368	.00175
			1500	.00018	.000758	.000193	....	....	.0362	1.1023	3.3	110	135	1.1290	1.244	1.306	1.368	.00235
			2000	.00018	.001010	.000193	....	....	.0362	1.1023	3.3	110	135	1.1290	1.244	1.306	1.368	.00294
32%	42½%	80%	2500	.00018	.001263	.000193	....	....	.0362	1.1023	3.3	110	135	1.1290	1.244	1.306	1.368	.00354
Case X.			**Large Plants—Motor Driven Air and Circulating Pumps; Direct Acting Compound Feed Pumps.**															
....	....	100	500	.00018	.000253	.000190	....	....	.0238	1.0891	2.2	100	123	1.1415	1.243	1.305	1.367	.00114
Combined Efficiency.			1000	.00018	.000505	.000190	....	....	.0238	1.0891	2.2	100	123	1.1415	1.243	1.305	1.367	.00175
			1500	.00018	.000758	.000190	....	....	.0238	1.0891	2.2	100	123	1.1415	1.243	1.305	1.367	.00235
			2000	.00018	.001010	.000190	....	....	.0238	1.0891	2.2	100	123	1.1415	1.243	1.305	1.367	.00294
32%	42½%	80%	2500	.00018	.001263	.000190	....	....	.0238	1.0891	2.2	100	123	1.1415	1.243	1.305	1.367	.00354
Case XI.			**Medium Plants—Motor Driven Air Pumps; Engine Driven Centrifugal Circulating Pumps; Direct Acting Feed Pumps.**															
....	50	150	500	.00018	.000253	.000198	....	.0253	.0371	1.1302	5.5	110	148	1.1154	1.261	1.324	1.387	.00057
Combined Efficiency.			1000	.00018	.000505	.000202	....	.0505	.0380	1.1580	7.5	110	177	1.0852	1.257	1.320	1.383	.00057
			1500	.00018	.000758	.000207	....	.0758	.0389	1.1858	9.5	110	197	1.0643	1.262	1.325	1.388	.00057
			2000	.00018	.001010	.000212	....	.1010	.0398	1.2136	11.5	110	200	1.0611	1.288	1.352	1.417	.00057
32%	50%	80%	2500	.00018	.001263	.000217	....	.1263	.0407	1.2415	13.5	110	200	1.0611	1.317	1.383	1.449	.00057
Case XII.			**Large Plants—Motor Driven Air Pumps; Engine Driven Centrifugal Circulating Pumps; Direct Acting Feed Pumps.**															
....	40	100	500	.00018	.000253	.000194	....	.0184	.0242	1.1092	3.8	100	140	1.1238	1.247	1.309	1.372	.00057
Combined Efficiency.			1000	.00018	.000505	.000197	....	.0367	.0247	1.1291	5.4	100	147	1.1165	1.261	1.324	1.387	.00057
			1500	.00018	.000758	.000201	....	.0551	.0251	1.1491	7.0	100	172	1.0904	1.251	1.314	1.376	.00057
			2000	.00018	.001010	.000204	....	.0735	.0255	1.1692	8.5	100	187	1.0747	1.257	1.320	1.383	.00057
32%	55%	80%	2500	.00018	.001263	.000208	....	.0919	.0260	1.1892	9.9	100	200	1.0611	1.262	1.325	1.388	.00057

NOTE—Boiler pressure is assumed 150 pounds gauge throughout.

All drains are discharged into hot wells.

Column "Cooling Water—W × H" gives weight of water per hour in pounds × total head in feet on circulating pump.

The above table allows 3 per cent. of total evaporation for oil burners, 1 per cent. for oil pumps, 2 per cent. for radiation.

The combined efficiency of auxiliaries is based upon 92 per cent. belt efficiency for belted auxiliaries and 85 per cent. motor efficiency for motor driven auxiliaries—85 per cent. engine efficiency for engine driven circulating pumps.

The horsepower given in last column is brake horsepower of engine for belted and direct connected auxiliaries and electric horsepower at switchboard for motor driven auxiliaries.

See Table No. 5 for per cent. reduction in output and per cent. increase in cost of fuel due to power driven auxiliaries.

The above figures will be modified in case of plants having economizers or superheaters.

*Written for THE JOURNAL by the Engineering Department of Chas. C. Moore & Co., Engineers, Inc.

TABLE NO. 5—POWER PLANT ECONOMY—CORRECTIONS FOR POWER DRIVEN AUXILIARIES.

This table to be used in connection with Table No. 4 in order to determine the net output or net economy of plant, corrected for power to drive power driven auxiliaries.

CHAS. C. MOORE & CO., ENGINEERS (INC.). SAN FRANCISCO, CAL.

Cooling Water W × H	Horsepower of Power Driven Auxiliaries Per Pound of Steam.	Per Cent Reduction in Output for Power Driven Auxiliaries — Pounds of Steam Per Indicated Horsepower Main Engine						Per Cent. Increase in Cost of Fuel Per Unit of Power — Pounds of Steam Per Indicated Horsepower Main Engine						Total Evaporation From and At 212° F. Per Pound of Steam, Main Engine Corrected for Power Driven Auxiliaries, Assuming 14 Pounds Per indicated Horsepower.			Equivalent Unit of Evaporation Per Pound of Steam to Main Engine to Drive Auxiliary Assum. 14 Pounds I. H. P.
		10	12	14	16	18	20	10	12	14	16	18	20	0%	+5%	+10%	
Case VII—Small Plants—Belted Air and Circulating Pumps; Direct Acting Feed Pumps.																	
500	.00094	1.044	1.253	1.462	1.671	1.880	2.089	1.055	1.269	1.484	1.700	1.916	2.134	1.267	1.330	1.394	.04338
1000	.00152	1.689	2.027	2.365	2.702	3.040	3.378	1.718	2.069	2.422	2.777	3.135	3.496	1.279	1.343	1.407	.05370
1500	.00208	2.311	2.773	3.236	3.698	4.160	4.622	2.366	2.832	3.344	3.840	4.236	4.846	1.290	1.355	1.419	.06368
2000	.00264	2.933	3.520	4.107	4.693	5.280	5.867	3.022	3.648	4.283	4.925	5.574	6.232	1.302	1.367	1.367	.07364
2500	.00302	3.356	4.027	4.698	5.369	6.040	6.711	3.472	4.196	4.929	5.674	6.428	7.194	1.311	1.377	1.442	.08041
Case VIII—Large Plants—Direct Connected Air Pumps; Engine Driven Centrifugal Circulating Pumps; Direct Acting Compound Feed Pumps.																	
500	.00037	.4111	.4933	.5755	.6578	.7400	.8222	.4128	.4957	.5788	.6622	.7456	.8290	1.254	1.317	1.379	.01040
1000	.00037	.4111	.4933	.5755	.6578	.7400	.8222	.4128	.4957	.5788	.6622	.7456	.8290	1.268	1.331	1.395	.02332
1500	.00037	.4111	.4933	.5755	.6578	.7400	.8222	.4128	.4957	.5788	.6622	.7456	.8290	1.261	1.324	1.387	.01450
2000	.00037	.4111	.4933	.5755	.6578	.7400	.8222	.4128	.4957	.5788	.6622	.7456	.8290	1.264	1.327	1.390	.01721
2500	.00037	.4111	.4933	.5755	.6578	.7400	.8222	.4128	.4957	.5788	.6622	.7456	.8290	1.270	1.334	1.397	.01997
Case IX—Medium Plants—Motor Driven Air and Circulating Pumps; Direct Acting Feed Pumps.																	
500	.00114	1.303	1.563	1.824	2.084	2.345	2.606	1.320	1.588	1.858	2.128	2.401	2.674	1.268	1.331	1.395	.03434
1000	.00175	2.000	2.400	2.800	3.200	3.600	4.000	2.041	2.459	2.881	3.306	3.734	4.167	1.281	1.345	1.409	.04561
1500	.00235	2.686	3.223	3.760	4.297	4.834	5.371	2.760	3.330	3.907	4.490	5.080	5.676	1.294	1.359	1.423	.05670
2000	.00294	3.360	4.032	4.704	5.376	6.048	6.720	3.477	4.202	4.936	5.681	6.437	7.204	1.307	1.371	1.438	.06760
2500	.00354	4.046	4.855	5.664	6.473	7.282	8.091	4.322	5.103	6.004	6.921	7.854	8.804	1.321	1.387	1.453	.07869
Case X—Large Plants—Motor Driven Air and Circulating Pumps; Direct Acting Compound Feed Pumps.																	
500	.00114	1.303	1.563	1.824	2.084	2.345	2.606	1.320	1.588	1.858	2.128	2.401	2.674	1.267	1.330	1.394	.02307
1000	.00175	2.000	2.400	2.800	3.200	3.600	4.000	2.041	2.459	2.881	3.306	3.734	4.167	1.280	1.344	1.408	.03443
1500	.00235	2.686	3.223	3.760	4.297	4.834	5.371	2.760	3.330	3.907	4.490	5.080	5.676	1.293	1.358	1.422	.04562
2000	.00294	3.360	4.032	4.704	5.376	6.048	6.720	3.477	4.202	4.936	5.681	6.437	7.204	1.306	1.371	1.437	.05662
2500	.00354	4.046	4.855	5.664	6.473	7.282	8.091	4.322	5.103	6.004	6.921	7.854	8.804	1.319	1.385	1.451	.06780
Case XI—Medium Plants—Motor Driven Air Pumps; Engine Driven Centrifugal Circulating Pumps; Direct Acting Feed Pumps.																	
500	.00057	.6515	.7817	.9120	1.042	1.173	1.303	.6558	.7879	.9204	1.053	1.197	1.320	1.273	1.337	1.400	.03813
1000	.00057	.6515	.7817	.9120	1.042	1.173	1.303	.6558	.7879	.9204	1.053	1.197	1.320	1.269	1.332	1.396	.03241
1500	.00057	.6515	.7817	.9120	1.042	1.173	1.303	.6558	.7879	.9204	1.053	1.197	1.320	1.275	1.339	1.403	.03619
2000	.00057	.6515	.7817	.9120	1.042	1.173	1.303	.6558	.7879	.9204	1.053	1.197	1.320	1.300	1.365	1.430	.06006
2500	.00057	.6515	.7817	.9120	1.042	1.173	1.303	.6558	.7879	.9204	1.053	1.197	1.320	1.330	1.396	1.463	.08772
Case XII—Large Plants—Motor Driven Air Pumps; Engine Driven Centrifugal Circulating Pumps; Compound Direct Acting Feed Pumps.																	
500	.00057	.6515	.7817	.9120	1.042	1.173	1.303	.6558	.7879	.9200	1.053	1.197	1.320	1.258	1.321	1.384	.01432
1000	.00057	.6515	.7817	.9120	1.042	1.173	1.303	.6558	.7879	.9200	1.053	1.197	1.320	1.273	1.337	1.400	.02724
1500	.00057	.6515	.7817	.9120	1.042	1.173	1.303	.6558	.7879	.9200	1.053	1.197	1.320	1.265	1.328	1.392	.01842
2000	.00057	.6515	.7817	.9120	1.042	1.173	1.303	.6558	.7879	.9200	1.053	1.197	1.320	1.269	1.332	1.396	.02113
2500	.00057	.6515	.7817	.9120	1.042	1.173	1.303	.6558	.7879	.9200	1.053	1.197	1.320	1.274	1.338	1.401	.02389

1. Cooling water W × H=Weight of cooling water per pound of steam on main engine × total head in feet on circulating pump.
2. The horsepower given in column No. 2 is brake horsepower of engine for belted auxiliaries and electric horsepower at switchboard for motor driven auxiliaries. See Table No. 4, on which this table is based.
3. This table is based on 150 pounds gauge steam pressure, 90 per cent. engine efficiency for belted and direct connected auxiliaries and 87½ per cent. combined efficiency of engine and generator for electrically driven auxiliaries.
4. The last column shows relative economy of auxiliaries, allowing for steam to main engine for power driven auxiliaries; also for heat returned from auxiliaries exhaust in case of steam driven auxiliaries.

TABLE NO. 6—POWER PLANT ECONOMY—POUNDS OF OIL CONSUMED PER INDICATED HORSEPOWER PER HOUR ON MAIN ENGINE.

CHAS. C. MOORE & CO., ENGINEERS (INC.) SAN FRANCISCO, CAL.

Engine Water Rate	Engine Water Rate Divided by Boiler Efficiency.	Total Equivalent Evaporation From and At 212° in Boiler, Including Auxiliaries, Per Pound of Steam Used on Main Engine																												
		1.16	1.18	1.20	1.21	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.30	1.31	1.32	1.33	1.34	1.35	1.36	1.37	1.38	1.39	1.40	1.42	1.44	1.46	1.48	1.50
10	13.3	.792	.806	.820	.826	.833	.840	.847	.854	.861	.867	.874	.881	.888	.895	.902	.908	.915	.922	.929	.936	.943	.949	.956	.970	.984	.997	1.011	1.025
11	14.7	.872	.887	.902	.909	.917	.924	.932	.939	.947	.954	.962	.969	.977	.984	.992	.999	1.007	1.014	1.022	1.029	1.037	1.044	1.052	1.067	1.082	1.097	1.112	1.127
12	16.0	.951	.967	.984	.992	1.000	1.008	1.016	1.025	1.033	1.041	1.049	1.057	1.065	1.074	1.082	1.090	1.098	1.106	1.115	1.123	1.131	1.139	1.147	1.164	1.180	1.197	1.213	1.229
13	17.3	1.030	1.048	1.065	1.074	1.083	1.092	1.101	1.110	1.119	1.128	1.137	1.145	1.154	1.163	1.172	1.181	1.190	1.199	1.208	1.216	1.225	1.234	1.243	1.261	1.279	1.296	1.314	1.332
14	18.7	1.109	1 128	1.147	1.157	1.167	1.176	1.186	1.195	1.205	1.214	1.224	1.233	1.243	1.253	1.262	1.272	1.281	1.291	1.300	1.310	1.320	1.329	1.339	1.358	1.377	1.396	1.415	1.434
15	20.0	1.188	1.209	1.229	1.240	1.250	1.260	1.270	1.281	1.291	1.301	1.311	1.322	1.332	1.342	1.352	1.363	1.373	1.383	1.393	1.404	1.414	1.424	1.434	1.455	1.475	1.496	1.516	1.537
16	21.3	1.268	1.290	1.311	1.322	1.333	1.344	1.355	1.366	1.377	1.388	1.399	1.410	1.421	1.432	1.442	1.453	1.464	1.475	1.486	1.497	1.508	1.519	1.530	1.552	1.574	1.595	1.617	1.639
17	22.7	1.347	1.370	1.393	1.405	1.417	1.428	1.440	1.451	1.463	1.475	1.486	1.498	1.509	1.521	1.533	1.544	1.556	1.567	1.579	1.591	1.602	1.614	1.626	1.649	1.672	1.695	1.718	1.742
18	24.0	1.426	1.451	1.475	1.488	1.500	1.512	1.524	1.537	1.549	1.561	1.574	1.586	1.598	1.611	1.623	1.635	1.647	1.660	1.672	1.694	1.697	1.709	1.721	1.746	1.770	1.795	1.820	1.844
19	25.3	1.505	1.531	1.557	1.570	1.583	1.596	1.609	1.622	1.635	1.648	1.661	1.674	1.687	1.700	1.713	1.726	1.739	1.752	1.765	1.778	1.791	1.804	1.817	1.843	1.869	1.895	1.921	1.947
20	26.7	1.585	1.612	1.639	1.653	1.667	1.680	1.694	1.708	1.721	1.735	1.748	1.762	1.776	1.789	1.803	1.817	1.830	1.844	1.858	1.871	1.885	1.899	1.912	1.940	1.967	1.994	2.022	2.049
21	28.0	1.664	1.692	1.721	1.736	1.750	1.764	1.779	1.793	1.807	1.822	1.836	1.850	1.865	1.879	1.893	1.908	1.922	1.936	1.951	1.965	1.979	1.994	2.008	2.037	2.065	2.094	2.123	2.151
22	29.3	1.743	1.773	1.803	1.818	1.833	1.848	1.863	1.878	1.893	1.908	1.923	1.938	1.953	1.968	1.983	1.998	2.013	2.029	2.044	2.059	2.074	2.089	2.104	2.134	2.164	2.194	2.224	2.254
23	30.7	1.822	1.854	1.885	1.901	1.916	1.932	1.948	1.964	1.979	1.995	2.011	2.026	2.042	2.058	2.074	2.089	2.105	2.121	2.136	2.152	2.168	2.184	2.199	2.231	2.262	2.294	2.325	2.356
24	32.0	1.901	1.934	1.967	1.983	2.000	2.016	2.033	2.049	2.065	2.082	2.098	2.115	2.131	2.147	2.164	2.180	2.197	2.213	2.229	2.246	2.262	2.278	2.295	2.328	2.360	2.393	2.426	2.459
25	33.3	1.981	2.015	2.049	2.066	2.083	2.100	2.117	2.134	2 151	2.169	2.186	2.203	2.220	2.237	2.254	2.271	2.288	2.305	2.322	2.339	2.356	2 373	2.391	2.425	2.459	2.493	2.527	2.561
26	34.7	2.060	2.095	2.131	2.149	2.166	2.184	2.902	2.220	2.238	2.255	2.273	2.291	2.309	2.326	2.344	2.362	2.380	2.397	2.415	2.433	2.451	2.468	2.486	2.522	2.557	2.593	2.628	2.664
27	36.0	2.139	2.176	2.213	2.231	2.250	2.268	2.287	2.305	2.324	2.342	2.360	2.379	2.397	2.416	2.434	2.453	2.471	2.490	2.508	2.526	2.545	2.563	2.582	2.619	2.656	2.692	2.729	2.766
28	37.3	2.218	2.257	2.295	2.314	2.333	2.352	2.371	2.391	2.410	2.429	2.448	2.467	2.486	2.505	2.524	2.543	2.563	2.582	2.601	2.620	2.639	2.658	2.677	2.716	2.754	2.792	2.830	2.869
29	38.7	2.298	2.337	2.377	2.397	2.416	2.436	2.456	2.476	2.496	2.515	2.535	2.555	2.575	2.595	2.615	2.634	2.654	2.674	2.694	2.714	2.733	2.753	2.773	2.813	2.852	2.892	2.931	2.971
30	40.0	2.377	2.418	2.459	2.479	2.500	2.520	2.541	2.561	2.582	2.602	2.623	2.643	2.664	2.684	2.705	2.725	2.746	2.766	2.787	2 807	2.828	2.848	2.869	2.910	2.951	2.992	3.033	3.074
31	41.3	2.456	2.498	2.541	2.562	2.583	2.604	2.625	2.647	2.668	2.689	2.710	2 731	2.752	2.774	2.795	2.816	2.837	2.858	2.880	2.901	2.922	2.943	2.964	3.007	3.049	3.091	3.134	3.176
32	42.7	2.535	2.579	2.623	2.645	2.666	2.688	2.710	2.732	2.754	2.776	2.798	2.819	2.841	2.863	2.885	2.907	2.929	2.951	2.972	2.994	3.016	3.038	3.060	3.104	3.147	3.191	3.235	3.278
33	44.0	2.615	2.660	2.705	2.727	2.750	2.772	2.795	2.817	2.840	2.862	2.885	2.907	2.930	2.953	2.975	2.998	3.020	3.043	3.065	3.088	3.110	3.133	3.155	3.201	3.246	3.291	3.336	3.381
34	45.3	2.694	2.740	2.787	2.810	2.833	2.856	2.880	2.903	2.926	2.949	2.972	2.996	3.019	3.042	3.065	3.089	3.112	3.135	3.158	3.181	3.205	3.228	3.251	3.298	3.344	3.390	3.437	3.483
35	46.7	2.773	2.821	2.869	2.893	2.916	2.940	2.964	2.988	3.012	3.036	3.060	3.084	3.108	3.132	3.155	3.179	3.203	3.227	3.251	3.275	3.299	3.323	3.347	3.395	3.442	3.490	3.538	3.586
36	48.0	2.852	.2.901	2.951	2.975	3.000	3.024	3.049	3.074	3.098	3.123	3.147	3.172	3.196	3.221	3.246	3.270	3.295	3.319	3.344	3.369	3.393	3.418	3.442	3.491	3.541	3.590	3.639	3.688
37	49.3	2.931	2.982	3.033	3.058	3.083	3.108	3.134	3.159	3.184	3.209	3.235	3.260	3.285	3.311	3.336	3.361	3.386	3.412	3.437	3.462	3.487	3.513	3.538	3.588	3.639	3.690	3.740	3.791

NOTE—Pounds of oil per indicated horsepower based on water rate stated in first column, assuming 75 per cent. boiler efficiency and 18,850 British thermal units per pound of oil. For other boiler efficiencies divide steam per indicated horsepower by boiler efficiency, using nearest corresponding figures in second column.

For other grades of oil the above figures are correct for the following:

Oil—British thermal units per pound, 19,100, 18,600, 18,360, 18,120, 17,900, 17,670.

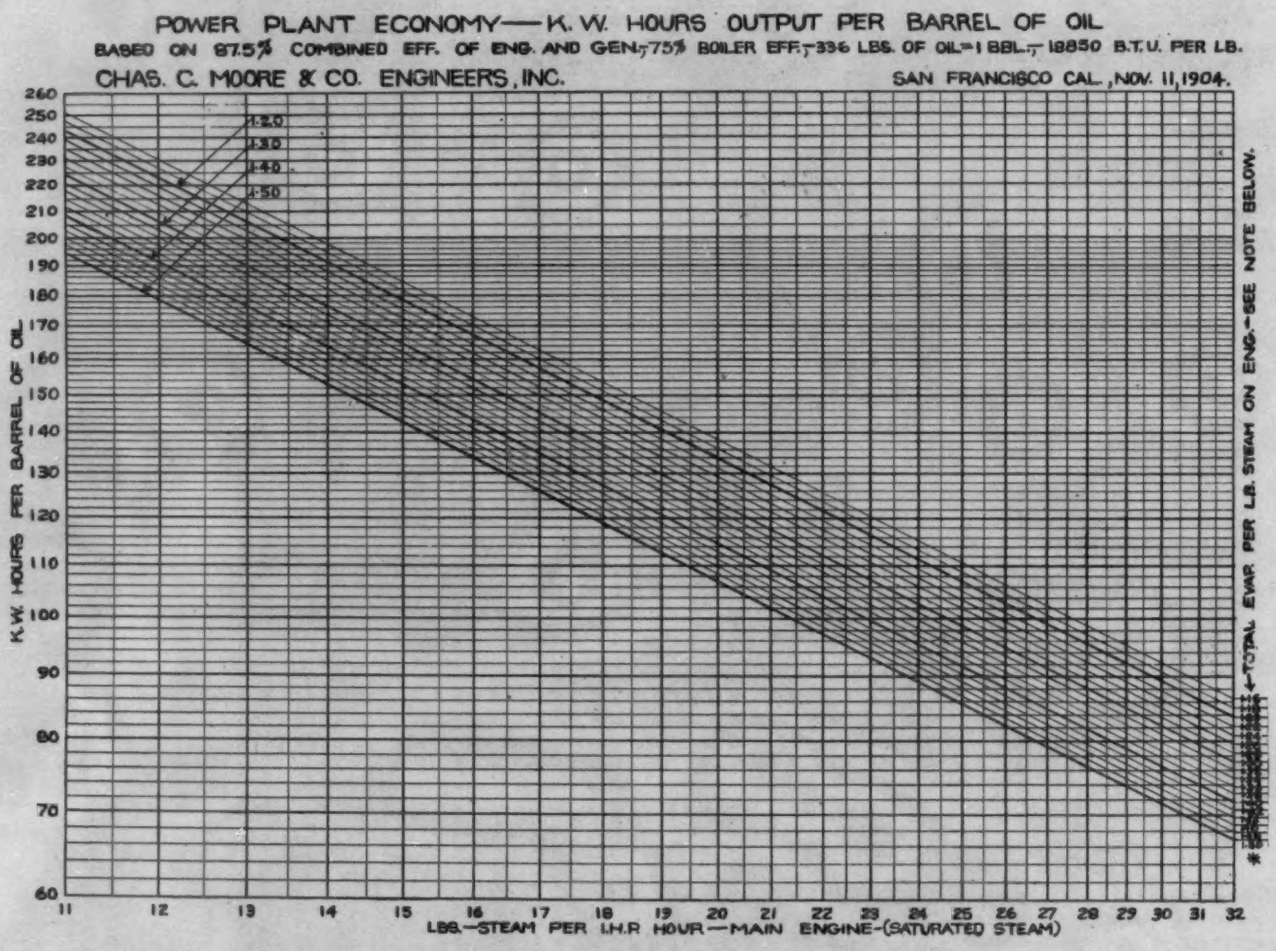
Boiler efficiency, per cent.— 74 76 77 78 79 80.

For "total equivalent evaporation, from and at 212°, in boiler, including auxiliaries, per pound of steam used on main engine," for various types and sizes of plants and various arrangements of auxiliaries see tables Nos. 3, 4 and 5.

The use of steam driven auxiliaries is generaly preferable to power driven auxiliaries in reserve steam plants, in plants having a wide variation of load, or more particularly in plants where fuel economizers are not installed. It is very desirable, however, to so decrease the supply of auxiliary steam as to maintain a low temperature of feed water entering economizers in order to obtain the highest economizer efficiency and plant economy. In such instances the use of the electrically driven auxiliaries in part becomes very desirable. It is still considered the best practice to retain the use of the direct steam driven feed pumps, also steam driven oil pumps, even when other auxiliaries are motor driven.

POWER DRIVEN AUXILIARIES-

Table No. 4 is calculated on this basis, giving cases from VII to XII, inclusive, covering all ordinary combinations of power driven auxiliaries. That portion of the auxiliary exhaust steam which is available for heating feed water is calculated and the temperature of feed water entering boiler accordingly determined. No allowance in this table is made for jacket or reheater drains for engines, for the use of economizers, or superheated steam. In these instances a further correction will be necessary. The table is self explanatory, showing the assumed efficiency of pumps and motors, which are thought to be entirely conservative. The figures given in column No. 16 for the total evaporation from and at 212 degrees F. in boiler per pound of exhaust steam supplied to main engine will require further correction in order to calculate the fuel economy per net horsepower output of main engine. These correcting factors, taking into consideration the use of electrically driven, belted, or direct connected auxiliaries are given in table No. 5. The first portion of this table indicates the per cent. reduction in output on account of power driven auxiliaries based upon various rates of economy of main engine. The second portion of table shows the per cent. increase in fuel cost per unit of output in case the figures used in column sixteen of table No. 4 are used to calculate the fuel economy of plant. The last portion of table No. 5 will be the most useful, giving the total evaporation from and at 212 degrees F. per pound of steam of main engine, corrected for power driven auxiliaries, assuming fourteen pounds of steam per indicated horsepower of main engine, so that the results are directly useful in calculations for fuel economy per net unit of output. Column 19 of table No. 4 is of interest, showing the actual horsepower required for power driven auxiliaries per pound of steam in main engine giving the brake horsepower of engine for belted and direct connected auxiliaries, and the electrical horsepower at switchboard corresponding to motor driven auxiliaries.


POWER PLANT ECONOMY—K.W. HOURS OUTPUT PER BARREL OF OIL
BASED ON 87.5% COMBINED EFF. OF ENG. AND GEN.; 75% BOILER EFF.; 336 LBS. OF OIL=1 BBL.; 18850 B.T.U. PER LB.
CHAS. C. MOORE & CO. ENGINEERS, INC.
SAN FRANCISCO CAL., NOV. 11, 1904.
1-20
1-30
1-40
1-50
K.W. HOURS PER BARREL OF OIL
260 250 240 230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60
11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
LBS.—STEAM PER I.H.P. HOUR—MAIN ENGINE—(SATURATED STEAM)
←TOTAL EVAP. PER LB. STEAM ON ENG.—SEE NOTE BELOW.
*

*Total evaporation in boiler from and at 212° including auxiliaries per pound of steam at 150 pounds gauge pressure used by main engine. See Tables Nos. 3 and 4.

TABLE 7

In order to compare the economy of power and steam driven auxiliaries, the last column of table No. 5 is deduced, showing the equivalent units of evaporation per pound of steam to main engine for power driven auxiliaries based on fourteen pounds steam per indicated horsepower, and, as well, allows for such steam driven auxiliaries as are listed in assumed plants. Referring to table No. 3* it will be noted that, for any given type of plant, steam driven auxiliaries are more economical than electrical or power driven, in such cases that the percentage of auxiliary steam to

*See THE JOURNAL, Volume XV, page 102, March, 1905.

heater is 10 per cent. of total steam or less. On the other hand, in such cases where the duty on circulating pump results in a large amount of auxiliary steam which cannot be entirely utilized in heater, there is a falling off in the relative economy of steam driven auxiliaries, making the use of electrically driven auxiliaries more desirable. These conclusions, however, are based on plants not having economizers, but will still apply, in some measure, even where economizers are installed.

In order to calculate the pounds of oil consumed per indicated horsepower per hour of main engine, Table No. 6 will be found very convenient. In obtaining these final results, it has been necessary to assume a boiler efficiency which has been taken at 75 per cent. and correspondingly 18,850 British thermal units per pound of oil. The foot note on table shows the corresponding

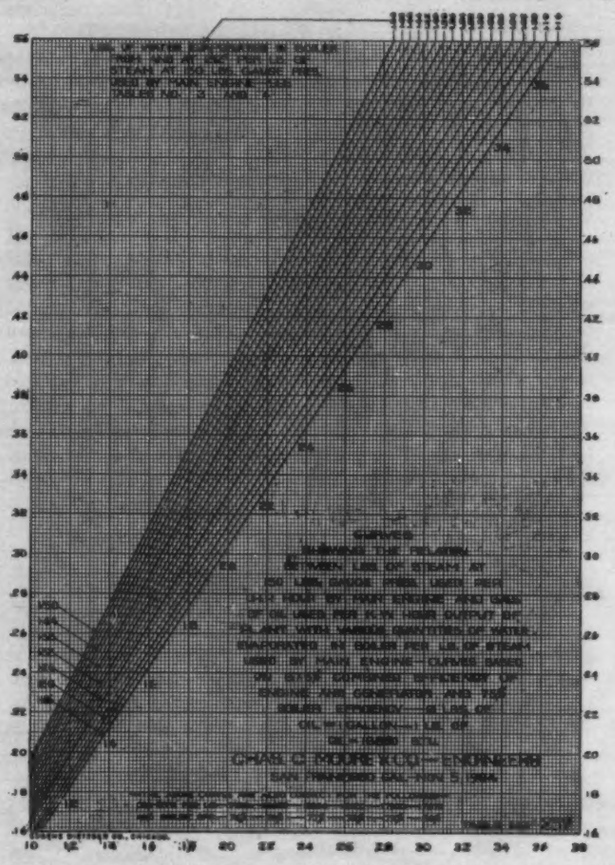


TABLE NO. 8. POUNDS STEAM PER INDICATED HORSEPOWER-HOUR MAIN ENGINE

equivalent values of heat units of oil and boiler efficiencies which can be used in table without further modification of final results.

For example, referring to Table No. 4, in case of a large plant having motor driven air and circulating pumps and direct acting compound feed pumps, assuming fifty pounds of cooling water per pound of steam and twenty feet head on pump, the product of F times H will be 1000, corresponding to which the total evaporation from and at 212 degrees F. in boiler per pound of steam of engine is 1.243. Referring to Table No. 6, assuming thirteen pounds per indicated horsepower steam consumption of main engine, there will be found opposite the value 1.24 the quantity of 1.101 which represents the pounds of oil per indicated horsepower of main engine. In order to obtain the correct value for useful output, we obtain from Table No. 5 corresponding correct value of evaporation in boiler 1.280, and again referring to Table No. 6 there will be obtained 1.137 pounds of oil per net indicated horsepower of main engine corrected for auxiliaries. In electric power plants all fuel economy should be referred to electrical output measured at the switchboard. The most common standard of reference is the kilowatt hours output per barrel of oil. Such results can be obtained directly from Table No. 7 herewith, which is based upon 87½ per cent. combined engine and generator efficiency, 75 per cent. boiler efficiency, 336 pounds of oil per barrel, each pound containing 18,850 heat units. The usage is also common of reporting the gallons of oil per kilowatt hour, in which case Table No. 8 will give such results directly. As a further example in the use of these curves, referring to Table No. 3, steam driven auxiliaries* corresponding to a large plant, W times H being 1000, the total evaporation from and at 212° is 1.252. Referring to Table No. 7 corresponding to twelve and one-half pounds per indicated horsepower of main engine, there will be found about 205 kilowatt hours per barrel of oil, or from Table No. 8 about .213 gallons of oil per kilowatt-hour.

All of the above results will require modification for different types of engines and generators depending upon economy and mechanical and electrical efficiency; furthermore, 75 per cent. does not represent the limit of boiler efficiency, as 80 per cent. is readily obtainable in the best types of boiler in large units. So that the figures above given do not represent the highest obtainable results from steam power plants on duty trials.

(Continuation in next issue.)

CONCERNING WRITE-UPS.†

BY ARTHUR WARREN.

ONE nuisance there is that all trade journalists know about, and that is the "write-up." It is a nuisance to the publisher; it is a nuisance to the manufacturer. But there is a vast difference between the "write-up" dreary, faultless and undisguised, and the timely article that has new value or interest for the commercial world, the factory, the mill, the executive, the artisan, the engineer, the miner, the financier, or the operative. These articles are legitimate if they are well written and informing. A good deal depends on that. The custom has grown up for manufacturers to supply articles to the trade and technical press. If these articles are not always well written, it is because of the difficulty we all experience, manufacturers as well as editors and publishers, in finding the men who can write well. On the other hand, if editors complain because they do not receive articles of sufficient merit, the owners of the papers must in some part blame themselves. The trade and technical press has added a new problem to the many problems of the manufacturer. I would hesitate to say how many requests a great engineering concern receives for articles to be written by its engineers who are experts in their respective specialties, for one might think the mere figures an exaggeration. But the fact is that if all these requests were complied with the engineers would have little time left for engineering. And, after all, designing and constructing and installing, to say nothing of selling, are what their employers pay them for. If the requests of the press are to be complied with, the manufacturers must employ a staff of writing engineers. This, however, would seem to be the proper function of the press itself.

PERSONAL.

George W. Holt has been appointed to the managership of the San Francisco office of the Postal Telegraph Cable Company, vice William Hearne, promoted to the superintendency.

Harvey J. Jeffs has been promoted from assistant chief operator to chief operator of the San Francisco office of the Western Union Telegraph Company.

B. A. Schroder, for some time attached to the St. Louis office of the Crocker-Wheeler Company, has been placed in charge of the New Orleans office of the Company. Mr. Schroder succeeds W. P. Field, who has been transferred to the Boston office.

*See THE JOURNAL, Volume XV, page 102, March, 1905.

†An excerpt from remarks made by Mr. Warren, manager of the department of publicity, Allis-Chalmers Company, before a recent meeting of the American Trade Press Association.

Efficiency Tests of an Impulse Water Wheel.*

BY JOSEPH N. LE CONTE,
Assistant Professor of Mechanical Engineering, University of California.

PART I.

The following article is intended to give an outline of the machinery used, the methods employed, and the preliminary results obtained in the tests of a three-foot impulse water wheel installed in the hydraulic laboratory of the University of California. The primary object of these tests has been to determine the efficiency of the wheel under varying conditions of head, size and type of nozzle, and form of bucket. At the present time the work is only partially completed, in fact not sufficiently progressed to show positively the results which it is hoped will finally be brought out, but the machinery and methods are practically completed.

The wheel, shaft, bearings, brake wheel and nozzles, complete, are the gift of the Pelton Water Wheel Company, of San Francisco, which has also furnished additional nozzles, buckets and minor parts when wanted. The wheel is mounted upon its standard wood frame in the central court of the Mechanical Engineering Building.

The head of water required for operation must, at the present time at least, be obtained from an artificial source. In order to accomplish this a series of concrete lined tanks have been sunk in the floor of the main court near its western end to serve both as supply and measuring reservoirs. The total area of these tanks is about 800 square feet, and they are excavated to a depth of twelve feet. Directly across the middle of this space a concrete wall has been run, leaving a tank twenty by twenty feet as a storage or supply tank, and the remaining area has still further been subdivided by walls, as will hereafter be described.

From the main supply tank a twelve-inch suction pipe leads to the extreme eastern end of the court, where the pumps are located. These are of the well known Quimby screw type. This form of pump was selected as being positive in action and yet operating without valves. A steady stream can in this way be obtained whose flow is pulseless, without the use of an air chamber, and practically unaffected by the pressure. At present there are two special pumps with five-inch inlets and four-inch outlets, drawing from a common suction and discharging into a ten-inch main leading back toward the wheel. By a proper arrangement of valves they can be thrown either in parallel or in series. These pumps are guaranteed to give one-half a second-foot under 300-foot head when running singly at 1200 revolutions per minute, and of course under twice that head when thrown in series. At present lack of power has prevented the latter test being carried out, but the single pump has been forced up to 335 feet, and then found to deliver 0.545 second-feet when run at 1100 revolutions per minute. They appear to give a remarkably high efficiency. In order to vary the head through any desired range a by-pass is taken off the main discharge and led back to the supply tank. This by-pass is operated by a double boiler blow-off gate with bronze seats and plugs, and serves to make a rough adjustment of pressure. The pumps are driven by a twenty-five horsepower direct current motor belted to a single pulley between the two. After passing through the wheel the water is led through a trough to a weir box six by twelve feet in area by two feet deep, and over a two and one-half-foot rectangular weir to a system of troughs and back to the supply or measuring tanks.

In determining the efficiency of any machine we are required to measure the ratio of the power output to the power input. In the present instance the efficiency will be expressed by

$$y = \frac{B.\ H.\ P.}{H.\ H.\ P.}$$

where $B.\ H.\ P.$ is the brake horsepower, or net output, and $H.\ H.\ P.$ is the hydraulic or water horsepower in the main pipe back of the nozzle. The efficiency expressed in this way is that of the whole machine, and in it the nozzle loss, the loss in the bucket, the windage and journal loss are all charged against the machine.

In measuring the above ratio we shall first consider the hydraulic horsepower term. This may be expressed by the formula

$$H.\ H.\ P. = \frac{Q\ w\ H}{550.}$$

where Q is the quantity of water (volume per second) acting on the wheel, w the weight of a unit volume (cubic foot) of water in pounds, and H the effective head in feet. Since w is a constant, the measurement of this power term involves the measurement of Q and H only.

The effective head H is the sum of the pressure and velocity heads in the main pipe near the nozzle, or

$$H = \frac{p}{w} + \frac{v^2}{2g}$$

p being the pressure in pounds per square foot, and v the velocity in the pipe expressed in fundamental units. The latter term is easily measured as soon as Q is known, and is practically insignificant in any case dealt with at present. The principal difficulty then lies in the measurement of p. This is usually obtained by means of an ordinary pressure gauge whose pipe is inserted at right angles to the direction of flow. Even in the best gauges graduated to single pounds, such as the eight-inch and twelve-inch test gauges employed, it was found difficult to rely on their indications within 1 per cent, For high pressures a fair accuracy

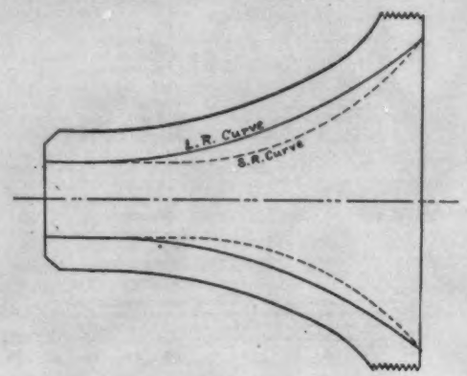


FIGURE 1

can be obtained, but this diminishes with the head, and for forty or fifty feet it is doubtful whether an accuracy of 5 per cent. can be obtained. A mercury column was not to be thought of, and as errors of such magnitude could not be tolerated, the following device was used, which is in reality nothing more than a platform gauge tester permanently installed.

A small bronze cylinder truly reamed is connected to the pressure pipe and fixed in a vertical position. Into this is inserted a hardened and ground steel piston, one-quarter square inch in area and three inches in length. Supported on the stem of this piston is a circular platform upon which can be placed weights, and the whole is rotated continuously by a cord driven by a small motor. The arrangement of the cord is as in Figure 1, so that no side thrust is exerted on the piston, and the continual rotation eliminates all frictional effects. The piston diameter can easily be verified to within less than one-thousandth of an inch, and the weights used are a set of Fairbanks standards, obtained for the purpose. For testing at a given head, therefore, the weights as deduced from the piston area are placed upon the platform, the pressure is raised by means of the main by-pass near the pumps

*Originally published in *The California Journal of Technology*, with material elaborations by the author for THE JOURNAL.

to a point a little above the required value, and then brought to the exact point by a small by-pass near the nozzle. A man at this latter valve keeps the platform "floating," and the accuracy of the apparatus is such that it will move throughout the entire range without the needle of the test gauge showing the slightest movement.

As the discharge coefficients of many of the nozzles tested came out very nearly unity, an additional precaution was taken to make sure that no appreciable error is introduced through this means of measuring pressure. The rotating platform was therefore compared directly with a small mercury column, on pressures up to twenty pounds per square inch, and in no instance did the difference amount to more than $\frac{1}{5}$ of 1 per cent.

In order to measure the second important term in the horsepower equation, namely the amount of water passing per second, the latter is led into a measuring box and over a two and one-half-foot rectangular weir. This, however, is not relied on to give the required amount, as the readings from even the best weirs cannot be depended on within 1 per cent. The water is therefore caught for a definite time and actually measured, in one of three measuring tanks. These are eleven by nineteen feet, eleven by seven feet and seven by seven feet in sectional area, and twelve feet deep, sunk in the floor of the court, and seperated by vertical walls of concrete eighteen inches thick. In the tests described below, the small tank, seven by seven feet in area, was used exclusively. This is calibrated throughout its entire heighth of ten feet by weighed volumes of water poured into it. The water level is read on a scale set by a hook gauge within an enclosed box used to damp the minor fluctuations of the surface. This hook can be easily set to within one thirty-second of an inch, and as the total rise in the water level is usually from six to ten feet, it is easily seen that a high degree of accuracy is obtained by this means. The following table gives the actual calibration of the tank and shows the variation of the tank constant due to slight changes in the rectangular cross section:

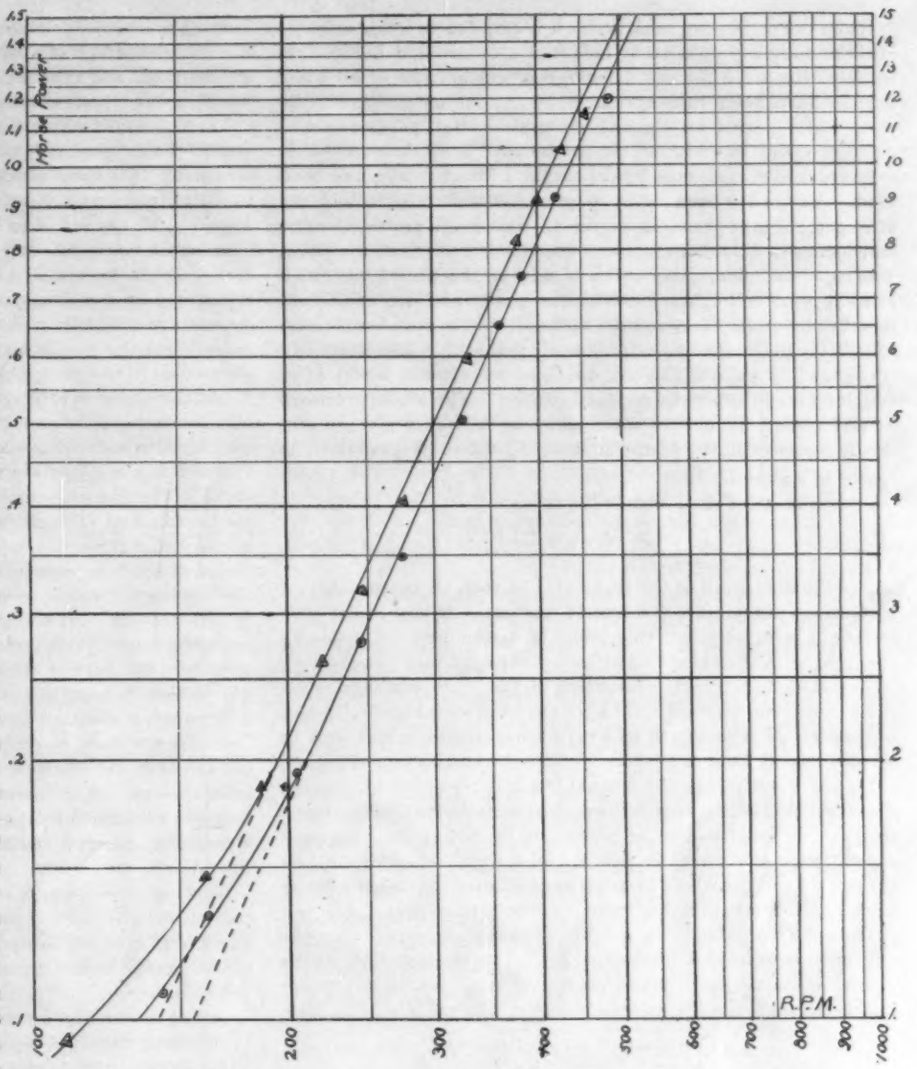


FIGURE 2

CALIBRATION OF TANK NO. 1.

Weights			Hook Gauge Reading		Constants	
Gross	Tare	Net	Centimeters	Rise in Surface	Volume Constant	Weight Constant
.....	.....	.....	4.72	. ....	.... .	.....
2848.0	335.5	2512.5	31.00	26.28	1.536	95.70
2804.3	343.5	2460.8	56.85	25.85	1.529	95.25
2805.3	329.2	2476.1	82.90	26.05	1.526	95.05
2864.2	326.4	2537.8	109.67	26.77	1.522	94.80
2806.1	328.6	2477.5	135.83	26.17	1.520	94.70
2824.6	331.8	2492.8	162.12	26.29	1.524	94.90
2814.5	327.7	2486.8	188.32	26.20	1.524	94.90
2835.0	329.0	2506.0	214.85	26.53	1.516	94.40
2808.0	325.5	2482.5	241.10	26.25	1.518	94.60
2826.4	338.5	2487.9	267.37	26.27	1.520	94.70
2815.8	599.5	2216.3	290.80	23 43	1.517	94.50
	Totals..	27,137	.....	286.08	1.523	94.85

Since the temperature of the water was 68 degrees F. the volume constant is obtained from the weight constant by using 62.31 as the weight of a cubic feet of water. Most of the nozzle tests were made with a nine foot rise in the tank level, hence the mean value of the volume constant, 1.523, has been employed.

When a test is to be made, the discharge from the weir is first led back to the supply tank until the conditions become steady. Then a sliding gate is dropped which cuts off the discharge from the supply tank, and all leakage is stopped by immediately folding up a sheet of gasket rubber which is tacked across the bottom of the trough. A similar rubber valve is then opened into the measuring tank, and this is allowed to fill, when the reverse process is gone through. Time is taken at the instant the gates are dropped.

In order to show the degree of accuracy attained by these methods of measuring pressure and quantity, the following observations are introduced:

MEASUREMENT OF QUANTITY THROUGH NOZZLE NO. 8. PRESSURE KEPT CONSTANT WITH ROTATING PLATFORM.

Time			Hook Gauge Reading			Quantity Cubic Feet Per Second
Start	Finish	Difference	Start	Finish	Difference	
2:19:00	2:32:30	13:30	4.20	276.15	271.95	.5113
2:59:30	3:13:00	13:30	6.00	277.81	271.81	.5111
1:49:00	1:54:00	5:00	4.87	105.50	100.63	.5109

When the measuring tank is full it is emptied in a few minutes into the main supply tank by means of a centrifugal pump electrically driven. After the discharge of coefficients of all plain nozzles have been thus obtained by actual measurement the results are plotted on logarithmic cross-section paper and used on subsequent tests without the necessity of tank measurements.

In order to measure the power output a Prony brake has been used. A rope has been found to give the best results, and the arrangement is as shown in Figure 2. The brake pulley, twenty-four inches in diameter and ten inches face, is keyed to the shaft. Two cast iron spiders, one on each side of the pulley and with arms at A, B and C, run loose on the shaft, and are connected together by cross-pieces at their extremities. A double rope surrounds the pulley and one end is made fast at B. The other end is engaged by a threaded hook operated by a hand wheel at F, which serves to apply the required tension. The whole is housed in and cooled by a free water spray at D. This gives a very steady pressure on the platform scale E, which is graduated to tenths of a pound.

The equation of the Prony brake is—

$$B.H.P. = \frac{2\pi l N}{33000}(P - W)$$

where l is the length of the brake arm in feet, N the number of revolutions per minute, P the scale reading at E, and W the overweight or lever weight. This latter is determined by removing the rope, with the exception of a short straight piece connecting A and B, and then taking the mean of the scale readings when the wheel is run forward and backward from some external source of power. N is measured by a revolution counter which can be thrown into and out of gear on the opposite end of the main shaft.

Finally the windage and journal loss is determined by running the wheel at different speeds through a transmission dynamometer from an external source of power, or by noting the change of speed, when the wheel is run up to a high velocity, the belt thrown off and the whole rotating mass allowed to come gradually to rest. In these tests the brake is entirely removed.

The apparatus above described is all that is necessary to make efficiency tests on this kind of wheel. The weakest link in the chain, as in all such power measurements, lies in the Prony brake, but with care highly satisfactory results are being obtained.

(Continuation in next issue.)

DAMPERS FOR SYNCHRONOUS MACHINES.*

BY E. L. WILDER.

HUNTING in a synchronous machine is a periodical variation in the speed above and below synchronous speed. This may occur either between alternators which are working in parallel supplying current to common feeders, or it may occur between an alternator generating power and a rotary converter or synchronous motor to which its power is supplied.

Consider the case of two alternators operating in parallel: When they are in synchronism the electromotive forces in the circuit including their two armatures are in direct phase opposition, and there will be no interchange of current if the two machines have similar wave forms and the excitation is the same. If, however, one machine lags, a resultant electromotive force will be developed which will cause a current to flow. This current takes power from the machine which is leading, and supplies it to the machine which is lagging, the obvious effect of which is to raise the speed of the lagging machine and to lower the speed of the leading machine. If on account of the inertia of the moving parts the machine which was lagging now forges ahead, the conditions are reversed, and thus begins an oscillation of current and speed which under certain conditions may become troublesome.

These currents which flow between two machines, thereby holding their average speeds to the same value, are called corrective currents. It is these which react upon the field flux and cause it to shift first in one direction and then in the other. Thus, in Figure 1, let the full line represent the normal field flux form. The dotted lines will represent roughly the limiting forms between which the flux will vary as the machine oscillates between a lagging and a leading position. This oscillation in speed may be restricted by the action of copper dampers placed upon the poles. For the sake of simplicity, disregard the presence of the flux set up by the field and assume the armature to be in rotation. When the machine is in synchronism, the flux set up by the armature rotates with respect to the armature at the same speed at which the armature is rotating, but in the opposite direction, so that the flux is stationary with reference to the frame of the machine. The armature may then be considered as a stationary electro-magnet, excited by direct-current, whose magnetic circuit is completed through the frame of the machine. When the condition of hunting prevails the armature may be considered as an electro-magnet which vibrates from its normal position, changing its strength as it swings back and forth, and becoming strongest when it is farthest removed from its normal position. If now we regard the field of the motor as excited, the resultant field due to field flux and armature flux will still vary since the field flux proper is constant for a giving constant field current.

If a copper sheet or copper grid is placed so that the flux will cut across it, the pumping or vibration will be dampened by the eddy currents set up therein according to Lenz's law. This is the function performed by the copper dampers placed on the poles of alternating current machines which are intended for parallel operation.

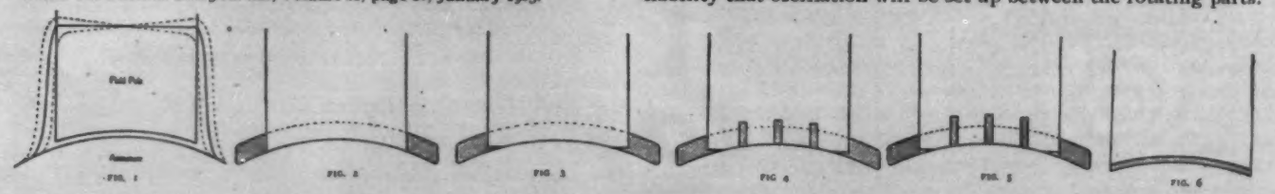
Hunting is very much like the swinging of a pendulum. If there is little friction a small force will keep up the vibration. The addition of the dampers is analogous to immersing the bob of the pendulum in a heavy oil which resists the motion of the pendulum.

One of the earliest forms of dampers is illustrated in Figure 2. It consisted merely of a heavy copper ring surrounding the pole tip. Its effectiveness as a damper is rather low. A later form is shown in Figure 3, the copper here being extended under the pole tip in the form of a lip. This modification greatly increased the damping effect. A still later form is illustrated in Figure 4, the damper being in the shape of a grid which is set into slots in the pole face. Figure 5 is a modification of this form. Figure 6 shows a very effective damper, which consists simply of a heavy copper sheet fastened to the face of the pole. This form can be used only with partially closed armature slots on account of the eddy currents which would otherwise be set up owing to the lack of uniformity in the flux.

The forms illustrated in Figures 3 and 4 are not much liable to eddy current losses and are used with open armature slots when a fairly large air-gap is used. The form illustrated in Figure 5 is set slightly back of the surface of the pole and is but little subject to eddy current losses. The above dampers are used with poles built up of laminated iron. Where solid poles are used, the surface of the pole itself acts as a damper, but it is subject to eddy current losses.

When machines are operated synchronously there is always the liability that oscillation will be set up between the rotating parts.

*From *The Electric Club Journal*, Volume II, page 26, January 1905.

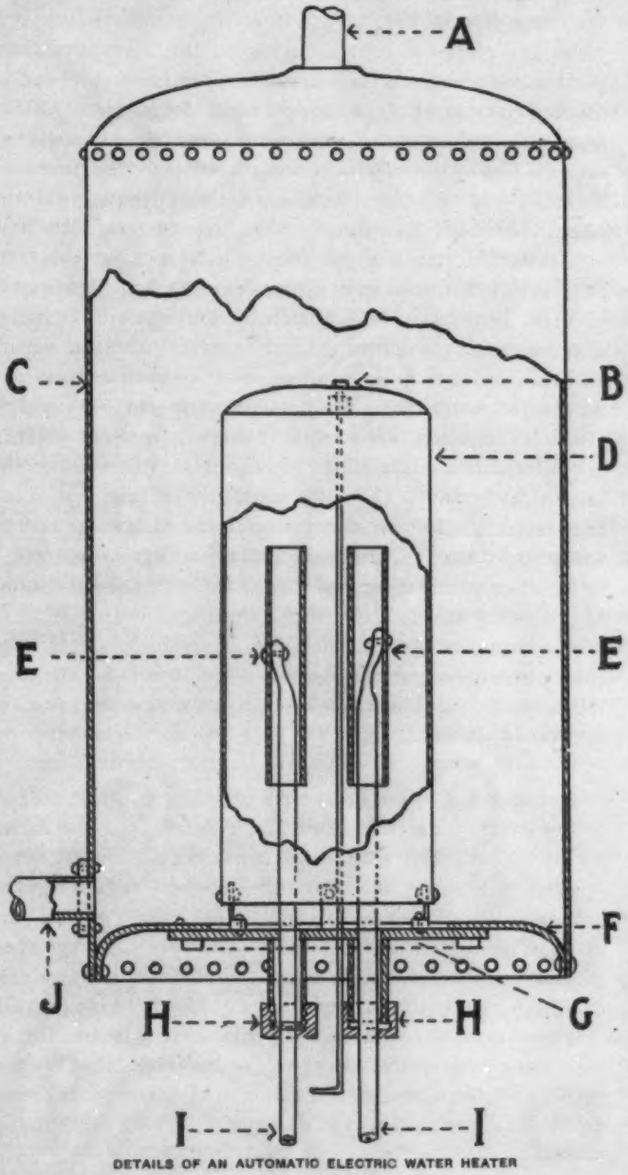


DAMPERS FOR SYNCHRONOUS MACHINES

If these are damped out quickly no harm is done. Excessive pumping not only reduces the stability of the system and renders the machines liable to be thrown out of step, but the resulting corrective currents occasion large copper losses. The function of the dampers is to offer a resistance to the oscillations when they first start and thus prevent their growing to the danger point.

AN AUTOMATIC ELECTRIC WATER HEATER.

IN many localities throughout the West where the winters are long and cold it becomes a great convenience to have a supply of hot water available to hydro-electric power plants, and to meet this requirement A. C. Pratt, superintendent of the Canyon Ferry Plant of the Missouri River Power Company, has devised an ingenious water heater which is operated electrically and which possesses the great advantage of absolute automaticity. The features of this interesting heater are shown in section in the accompanying sketch, wherein *A* represents the hot water outlet consisting of a one inch pipe; *B* is the air and steam vent pipe and valve; *C* is the fifteen-gallon galvanized iron tank which is cut away in part to show the steam can; *D* is the steam can which is closed at the top and open at the base and part cut away in the figure to show the position of the electrodes; *E* represents the two electrodes which consist of respective pieces of one-inch iron pipe sketched in section to show the method by which the current supply wires are connected. No material electrolysis to these electrodes has been noted in three years of service. *F* shows the concave bottom of the main tank; *G* is a removable plate with a water tight gasket; *H H* are stuffing boxes; *I I* are extra insulated rubber wires supplying current to the electrodes, and *J* is the one-inch pipe through which cold water is supplied to the tank.



DETAILS OF AN AUTOMATIC ELECTRIC WATER HEATER

Its construction is based on the principle of a water rheostat operated under an inverted tank or can, all being enclosed in an outer tank, the water in which is either under pressure or otherwise as may be desired. The inner or inverted can contains electrodes designated in the diagram as *EE* which are seperated a distance of an inch and a quarter and on which is maintained a pressure of 500 volts in sixty-cycle alternating current. Obviously, any steam which is formed by the electrolysis of water rises within this inner can, and as its pressure increases it drives the water therein downward, hence off, the electrodes, thus automatically controlling the current consumption and keeping the can filled nearly full of steam, which in turn maintains the temperature of the water in the outer tank at a point near to boiling. The sketch shown presents the original form of heater which was installed three years ago in the Canyon Ferry Power house, and which is still in operation, and it is interesting to note that while its maximum energy consumption is approximately five kilowatts when both tanks are filled with cold water, this consumption decreases gradually as the temperature of the water, as well as its position in the inner tank lowers, until it reaches a minimum of three-tenths of a kilowatt. The capacity of the outer tank is fifteen gallons, and it is but partially protected from the cold air.

Further reference to the drawing will show that at *A* is located a small valve by means of which trapped air may be let from the inner can, or, if desired, steam may be blown from it in order to hasten the heating of the water in the outer tank, if an extra amount of hot water be desired quickly. The steam can and electrode are mounted on the bottom plate of the main tank to which they are attached by cap screws. It is desirable that the tank should be insulated and that its inlet and outlet pipes should consist of rubber hose to prevent the grounding of the current supply. The conditions shown are those which have been found by experiment to best fit the heating of the water of the Missouri River.

A "HIGH TENSION" TELEPHONE.

A TELEPHONE is being made by a concern in Stockholm, Sweden, which embodies features of unusual conception. It is designed principally to overcome the danger of high tension currents where the telephone wires and the former are on the same pole line. The instrument is intended to be fixed on the wall as near the ceiling as possible, thus removing the induction coil, generator and all susceptible parts of the instrument far away from a point where they might come in contact with a person using the instrument. The transmitter and receiver conductors are then led down to a normal height, being covered with Indian rubber tubes which insulate them thoroughly against the high tension currents. From the switch hook a cord is led down and a weight attached to it which keeps the hook down when not in use. In place of the usual crank on the ordinary telephone which actuates the generator, a pulley is fixed, connected with a cord to a similar pulley, which is attached to the wall further down. This pulley has a crank which enables one to ring the generator.

AN EXCELLENT TRANSMISSION RECORD.

In its three years of operation the Northern California Power Company has suffered service interruptions aggregating two hours and fifty-four minutes, not one second of which occurred at the power house. These interruptions were due to an eagle and a goose short circuiting the line, and to a flood in the Sacramento River which washed out a pole supporting the transmission span across the river.

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EDITORIAL.

IN THE MATTER OF CO-INSURANCE

No more unwelcome visitor than fire ever enters the portals of any manufacturing plant, for it not only exacts the extreme penaly for carelessness, or inattention, or neglect, but at the same time it wreaks a terrible vengeance for outraged prudence. In comparison with it a strike, however widespread—which is commonly regarded as being the most disastrous of industrial disturbances—is but a pastime; for while the strike merely checks production, the fire not only checks production but gives absolute destruction to values.

Apropos of this it is a fact that the people of the United States are the most wasteful in the world in this direction. Fire losses being the barometer of insurance rates, it is interesting to note that the fire cost per thousand dollars of value of property insured is twelve times greater in the United States than in Great Britain, where poor construction is prohibited by law. and it is twenty times greater than in Italy, where the construction is still better and the conflagration hazard is practically eliminated.

But nowhere, except in a general conflagration occurring in a great city, do the immediate effects of a fire portend such instant disaster to practically every industry as when it consumes the plant of the corporation that renders a quasi-public service—to the gas works and water works, to the electric light and power plant and to the street and interurban railway system. As the months roll by the majority of these industries are gravitating toward a common interest in that electricity is becoming the medium for their operation, and the time will soon come—it is already here in many localities—when practically every lighting, power and railway transportation facility of the community will be dependant upon a single electric generating station. In these instances this great power house becomes the heart that pumps the life blood through every artery of industry. How great is the calamity, then, when fire stops its beating. Days, weeks and sometimes months must pass before normal conditions are restored—a period that memory ever regards as a racking nightmare of work and worry, of suspense and expense, and of anxiety and apprehension, to all of which loss of income is but a minor factor. Yet despite this no manager ever expects his plant to be burned. Others may—Seattle, Victoria, Helena, Butte, San Jose, Eureka, Oakland, Colgate and San Francisco have all had destructive station fires—but *his* plant will not burn. Then comes the fire that proves his puerility and makes him a past master in the fellowship of trouble.

The inexplicable situation which arises in the settlement of practically every fire loss is referred to with wonderment. It is that works' managers will place insurance on the properties under their supervision, ignoring utterly the fact that an insurance policy is a clean and clear-cut contract wherein the insurance companies, for and in consideration of premiums paid and in further consideration of certain well defined obligations assumed by the assured, contract to reimburse the assured for any loss or damage occurring by fire to the premises specified. The policy is issued, the premium is paid, the solemn contract is entered into, but its terms are as a sealed book to the assured despite the fact that they are fully set forth in the policy, the document is filed away, and the transaction is forgotten beyond entering a notation concerning expiration, until forsooth the fire occurs and the manager finds in all probability that he has done an unpardonable thing from the standpoint of business ethics in signing up a vital contract without having acquainted himself with its provisions. Then comes the task that is invariably the most difficult which is encountered in all insurance transactions, namely, and to use an insurance phrase, that of "adjusting the assured," or in other words of acquainting him with the conditions of the policy-contract and of convincing him that he is in honor bound to respect its terms. Particularly is this the case when co-insurance prevails—and it is the exception when electric station risks are not insured under the co-insurance clause.

Co-insurance is a special form of policy-contract wherein the contracting parties mutually agree between themselves that for the additional considerations, first, of a positive guarantee made by the assured regarding the actual value of the property covered, and, second, the assured agreeing to maintain insurance to a specified percentage thereof, the insurance companies grant a rate of premium less than that which would otherwise prevail.

There is no doubt as to the equity of the plan, for as insurance rates are based upon the loss ratio, that is upon ratios existing between the amount of premium increase and the amount of loss and damage occurring thereunder,

it is obviously fair to all concerned that the ratio existing between the sound or market value of the property insured and the amount of insurance carried thereon should be pre-defined. Were it otherwise, as it ordinarily is, it is but human nature for insurance to be carried only to an extent that would probably cover any loss occurring thereto without regard to its relation to sound values or specific coverings. For instance, if a modern station valued at say $500,000.00 carries $50,000.00 insurance, it is improbable that any fire of consequence which would visit it would do less damage than the insurance would cover. Such a fire would be regarded as a total loss—that is the amount of insurance carried by the companies would be totally lost—a 100 per cent. loss—albeit the property was damaged to the extent of but 10 per cent. of its value, and the rate of premium must be fixed accordingly. On the other hand, if say $250,000.00 in insurance be carried on the risk, the liability of loss and damage would be just the same as before, the probability of salvage would be greater and the fact that the risk would be a better one is recognized by a lower rate of insurance.

Thus arises co-insurance, wherein the assured in consideration of a lower rate of premium guarantees to place insurance on his property to a certain percentage of its sound value, failing to do which he becomes a co-insurer with the insurance companies to the extent of the deficit, if any, which may exist at the time of the fire, between the agreed percentage of actual or sound value of the property and the amount of insurance carried. If it be found during the appraisement which follows the fire that the assured has correctly presented the value of the property insured, and has carried insurance thereon to the percentage specified, then the co-insurance clause does not apply; if, to the contrary, the assured defaults either in correctly valuing the worth of the property, or in carrying insurance to the amount specified, then co-insurance prevails and the assured bears his proportion of the loss and damaged occurring to the property to which the clause applies.

There are four modes under which an electric power station, for instance, may be insured, viz., with the full or 100 per cent. co-insurance clause, with 80 per cent. co-insurance, with 50 per cent. co-insurance, and with no co-insurance clause, and the rate of premium for insurance under each mode decreases in inverse proportion to the amount of co-insurance carried, being a minimum with the 100 per cent. co-insurance and a maximum with no co-insurance. The standard form of co-insurance clause for, say 80 per cent. co-insurance, is as follows:

> It is a part of the consideration of this policy and the basis upon which the rate of premium is fixed, that the assured shall maintain insurance on the property above described to the extent of four-fifths of the actual cash value thereof, and failing so to do the assured shall be an insurer to the extent of such deficit, and in that event shall bear a proportion of any loss. This clause shall apply to each item above described separately.

Before proceeding to demonstrate the application of co-insurance by citing an actual case, it is well to explain the terms "sound value," "total loss" and "loss paid," these being the three factors which enter into co-insurance determinations.

The "sound value" of a piece of insurable property is its actual cash value on the day before the fire, and consists of its value as new, depreciated by a percentage representing its period of service. Its new cost on the day before the fire may be more or it may be less than its cost when purchased; hence its sound value is generally its present cost value minus depreciation, although instances are known where the sound value shows an appreciation over the original cost despite deductions for depreciation from use.

The term "total loss" as here applied is literal in that it means the total loss and damage occurring to the property irrespective of any insurance condition.

"Loss paid" means the proportion of the "total loss" to be paid by the insurance company or companies under the co-insurance clause prevailing. The difference between the actual loss occurring and the "loss paid" by the fire underwriters represents the proportion of loss borne by the assured under the co-insurance clause.

To illustrate the working of this much-discussed clause, reference may be fittingly made to an actual occurrence. Early in 1903 there was burned a general power house, situated in a city of the Rocky Mountains. Under one of the items of the policy, insurance to the amount of $1500.00 was placed on "arc lamps, switches, wire, wood switchboard and apparatus, duplicate machinery, armatures and other electrical appliances, tools and implements, all while contained in the above described power house." To this item there was attached by mutual agreement the full or 100 per cent. co-insurance clause. A few days before the fire occurred a large shipment of new pole transformers was received and stored in the station. The value of these transformers was above $6600.00, and it was found on appraisement that the sound value of property covered by this particular item was $8493.28, on which insurance to the amount of but $1500.00 was carried, whereas the assured agreed to carry insurance to the full value of the property, or $8493.28. In this the assured defaulted.

In effecting a settlement under the policy it was found that the sound value of the property covered under this particular item was $8493.28; that the "total loss" occurring thereto was $5435.97; that the loss paid thereon by the insurance company was $1136.66, and that the proportion of loss paid by the electric light and power company under co-insurance was $5299.31.

The amount of insurance paid by insurance companies under items upon which co-insurance prevails is found by proportion thus:

Sound Value: Amount of Insurance :: "Total Loss": "Loss Paid."

Expressed in another way, the proportion of loss borne by the insurance companies is:

$$\frac{\text{Amount of Insurance}}{\text{Sound Value}} \times \text{"Total Loss."}$$

And all this means what?

Briefly, it means that an insurance policy is a contract that is vital to the financial stability of any business, and it means, further, that the corporation manager who does not master the terms of this vital policy-contract is culpable in not properly safeguarding the interests entrusted to his care.

INTERURBAN RAILWAY DEVELOPMENT

The operation of railroads by electricity is an all important subject for consideration today by every one connected in railroad work. For some years electric city and interurban railway systems have been steadily increasing in importance and now interest is being centered in the use of electricity for the handling of the heavy traffic of steam railroads. The occasion for this activity results from the necessity of providing adequate, healthful and economical transportation in the large cities for the vast throngs of suburbanites who daily travel to and from the business centers as well as for the through passenger traffic which already demands proper and expeditious handling at the city terminals. An exhaustive and carefully studied investigation into these existing conditions and the development of electrical locomotives and the systems of traction which are now being put forth as a solution to the problem is presented in Mr. Robert McF. Doble's paper before the Pacific Coast Railway Club which is concluded in this issue of THE JOURNAL.

A point of most vital interest that is brought out in Mr. Doble's paper is the availability of Pacific Coast water powers for the operation of railroads. We have almost unlimited power possibilities in the streams of the Sierras and the remarkable success that has attended the utilization of comparatively few of these water powers has doubtless laid the foundation for a remarkable electrical development that will eventually embrace the steam railroads as thoroughly as it has the city and interurban systems. The advantages of electrical operation for suburban and terminal lines where a frequent service is maintained have been frequently demonstrated, and the incentive to make the necessary heavy expense in changing over from the old system to the new needs only the crystallized public demand for improvement or the persuasive effect of ruinous competition with more modern roads. It is interesting in this connection to note the figures recently reported as coming from the Southern Pacific Company in its consideration of the feasibility of changing the local steam lines in Oakland, Berkeley and Alameda to electric traction. The report estimates that the cost of supplies, maintenance, train crew and power per train-mile on a steam road is 34 cents as against 21.2 cents on an electric road, thus showing a gain in operating expenses for the latter of 13.8 cents per train-mile.

Mr. Doble's discussion of the local conditions now existing in electric railway power supply on the Coast is an interesting one, and it will probably surprise many unfamiliar with the local conditions to learn that railways in so many of the Coast cities from Vancouver to Los Angeles are already being operated by power generated at and transmitted from hydro-electric plants. Realizing the full import of the rapid and substantial expansion of electric railways that is now taking place about San Francisco, San Jose and Los Angeles, there is predicted for the great fertile valleys of the San Joaquin and Sacramento a network of railroads radiating from the principal cities, intersecting with each other, tapping the rich agricultural and mining sections and embracing through trunk lines for handling transcontinental traffic. Already the large cities have their local and suburban lines, and long distance projects are day by day materializing about such points as Marysville, Grass Valley, Chico, Colusa, Sacramento, Stockton, Merced and the Yosemite. The water powers conveniently located by nature the entire length of the valley are merely awaiting the demands of the railways, and the need for the latter, already upon us, will soon have to be satisfied by the building of many new lines and the electrification of those already in operation.

CONCERNING BIG GENERATORS.

Seldom does an opportunity arise necessitating an editorial reference to an article appearing in the industrial columns of THE JOURNAL, but a noteworthy instance proving the assertion is found in the description given elsewhere in this issue of the extraordinary motor-generator set that has been built in the Bullock works of the Allis-Chalmers Company. It consists of an 8000 horsepower synchronous motor, direct-coupled to a generator rated at 5750 kilowatts and running at a speed of 300 revolutions per minute, the combined set having an aggregate rating of 12,000 kilowatts, or nominally 16,000 horsepower. It is furthermore significant of the advances that have been made in machine testing to state that by the Behrend system this set was run under full load test conditions amounting to 7200 kilowatts on the generator with an expenditure of no more than 300 kilowatts in order to produce the same losses in the machines which existed during the test. In other words, the expenditure of 300 kilowatts enabled the development of power in the two machines to the total volume of 12,000 kilowatts. To the layman this savors of "boot strap lifting"; to the engineer it is everyday practice.

The building of such stupendous machines is not unparalleled, for even larger single units are in daily operation; but their appearance gives rise to the inquiry where is to be the end in the matter of size and output in single generators. In answer we can only reply that we know not, for while in the Centennial year we wondered at the then great 1000 horsepower Corliss engines that proved to be the cynosure of all eyes at the Philadelphia exposition, now we find less wonderment in viewing the working of engines having twenty times the capacity of that noteworthy pioneer. And so it is with dynamos, for even the once great 5000 horsepower machines at Niagara have sunk to the commonplace in the marvellous advance of engineering development. The Shawinigan Falls motor-generator set is, therefore, but the last milestone that has been passed in its branch of electrical progress.

ALTERNATING CURRENT LABORATORY TESTING.

BY GEORGE H. ROWE.

PART I—CONTINUED.

HYSTERESIS AND EDDY LOSSES.

These losses appear in all forms of alternating current machinery. It is therefore important to understand and determine the laws governing them.

The energy lost in hysteresis per second is

$$\frac{1}{4\pi}\int_{-B}^{B} H\,dB \times V \times \sim \times 10^{7} \text{ watts.}$$

The watts lost in hysteresis are conveniently plotted as in Figures 23 and 24, where watts per cubic inch or per pound per cycle are plotted as ordinates, and B in lines per square inch as abscissæ. These curves are due to Steinmetz.

Steinmetz' approximation is

$$\text{watts} = n \times B^{1.6} \times V \times \sim \times 10^{-7}$$

where n is the hysteresis constant. The value assumed in the curve (Figure 23) is .0033. V is the volume of the iron in cubic centimeters, and B the density in lines per square centimeter.*

From theoretical conditions it can be shown that the eddy loss is

$$W_e = 1.645 \times V \times d^2 \times \sim^2 \times B^2 \times 10^{-11}$$

in which d is the thickness of the laminations.† The total loss in the magnetic circuit can therefore be expressed as

$$W_t = n \times \sim \times W \times B^{1.6} \times 10^{-7} + 1.646 \times V \times d^2 \times \sim^2 \times B^2 \times 10^{-11}.$$

Connect the magnetic circuit, the losses of which are to be determined, as, for instance, the secondary of a transformer, as shown in Figure 25.

Measure the current, watts and electromotive force. Correct for instrumental errors and observe the following values:

Volts	Watts	Speed	B (Calc.)

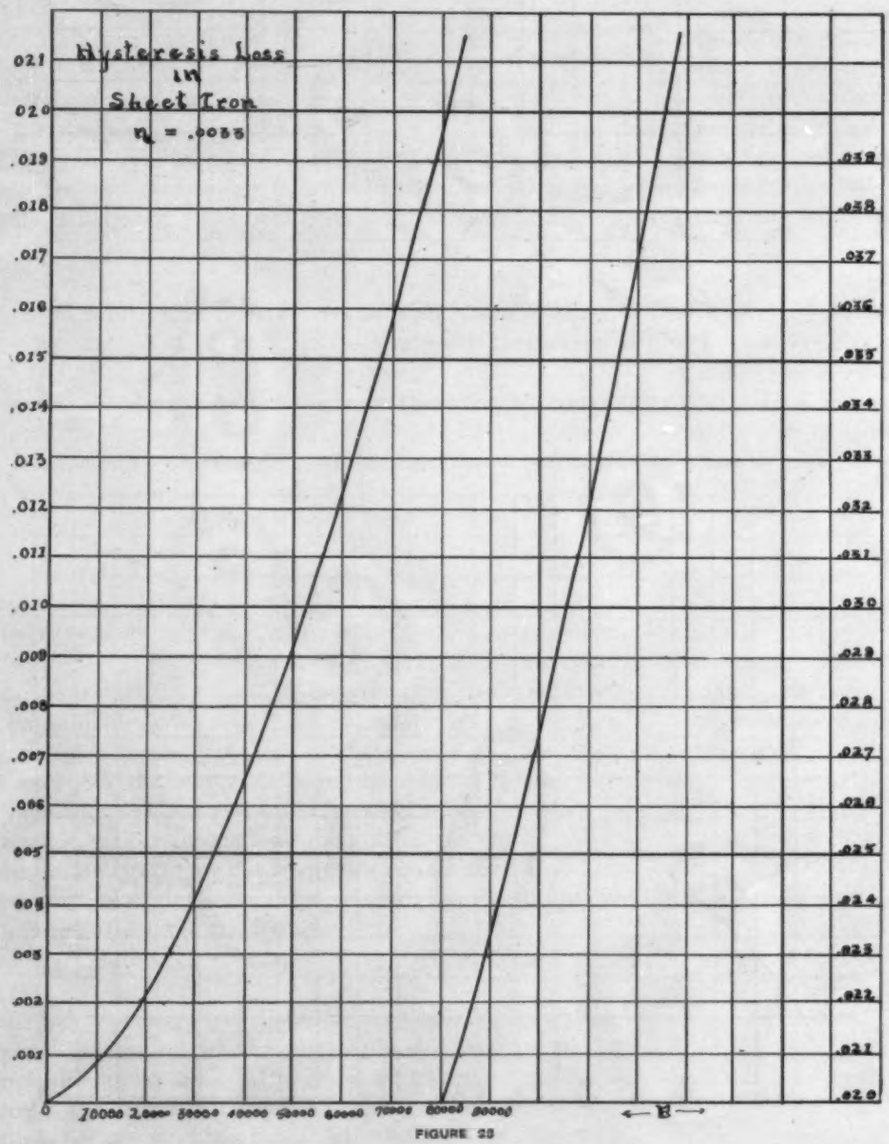


FIGURE 23

Plot results as in Figure 26.

Next change the frequency by changing the speed of the alternator or by means of a frequency changer, and observe and plot a new series of values for

Volts	Watts	Speed	B (Calc.)

The equation $W_t = n \times \sim \times V \times B^{1.6} \times 10^{-7} + 1.645\, V \times d^2 \times \sim^2 \times B^2 \times 10^{-11}$ is of the form $W_t = a \sim + b \sim^2$ and for a different frequency, B *remaining constant*, the equation is $W_t = a \sim^1 + b \sim^{1\,2}$

From the two figures similar to Figure 26 determine the watts for the same value of B and determine a and b. Then plot the separated hysteresis for each electromotive force and each frequency. Verify the equation $W_h = n \times \sim \times B^{1.6} \times 10^{-7}$.

TWO-PHASE AND THREE-PHASE CIRCUITS.

The number of phases of a polyphase circuit may be increased or diminished. A special case of this principle is illustrated in Scott's‡ method of transforming from two-phase to three-phase, or the reverse.

*Peenomena, page 116,

†phenomena, page 129.

‡*Electrical World*, Volume XXIII, page 358.

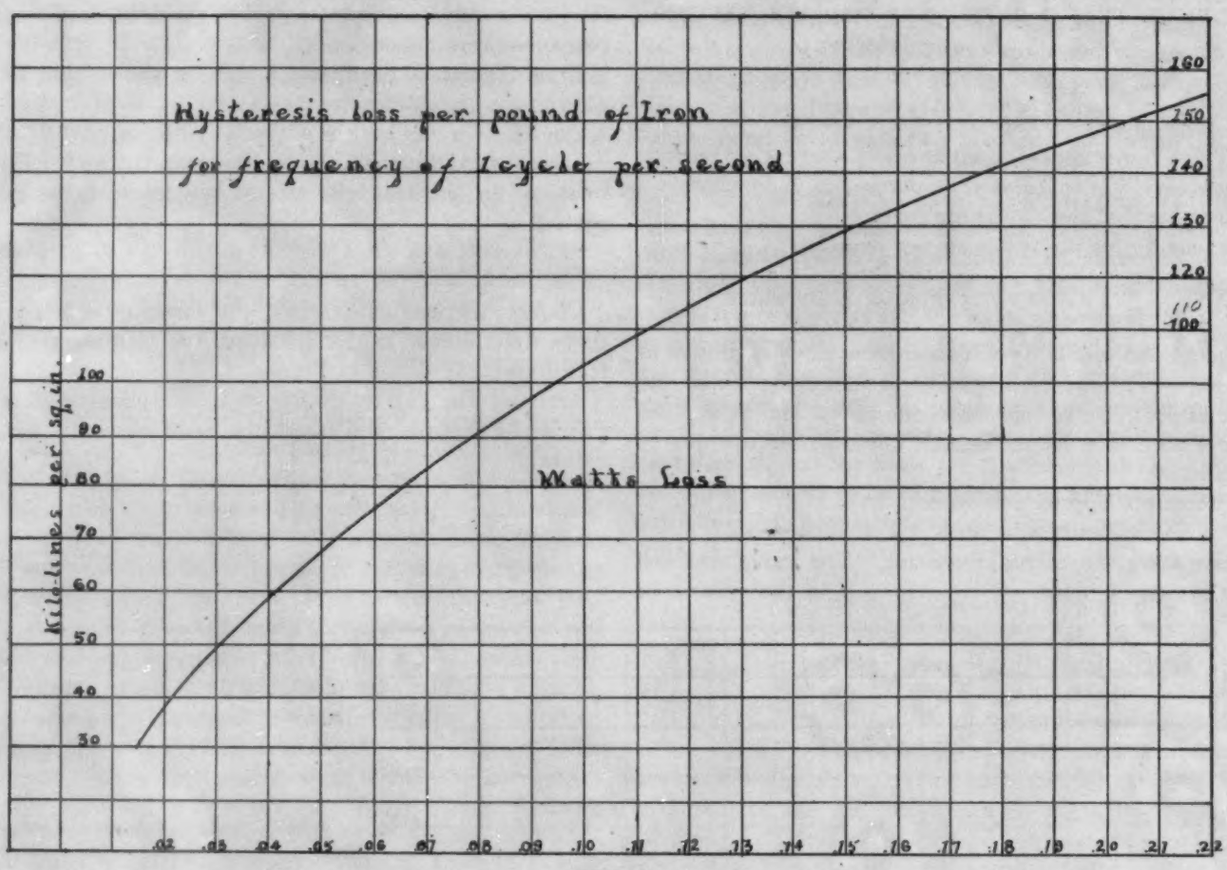


FIGURE 24

The diagram of connections is as in Figure 27. One two-phased circuit is connected to the primary *mn*. The other is connected to *op*. The secondary S is divided in the middle, and from this point connection is made to S^1 as shown. Then if there are $\sqrt{3}/2$ times as many turns in S^1 as in S, the electromotive forces between E and F, F and G and G and E are equal and differ in phase by 120 degrees.

The reason for this is shown in Figure 28.

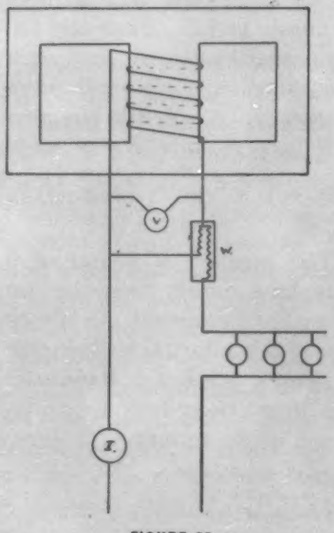


FIGURE 25

S and S^1 are at right angles to each other, and form an equilateral triangle.

Tan $60° = \frac{S^1}{\frac{S}{2}}$ or $S^1 = \sqrt{3}\,\frac{S}{2}$. Hence coil S^1 must have about 86 per cent. as many turns as S. The equal-

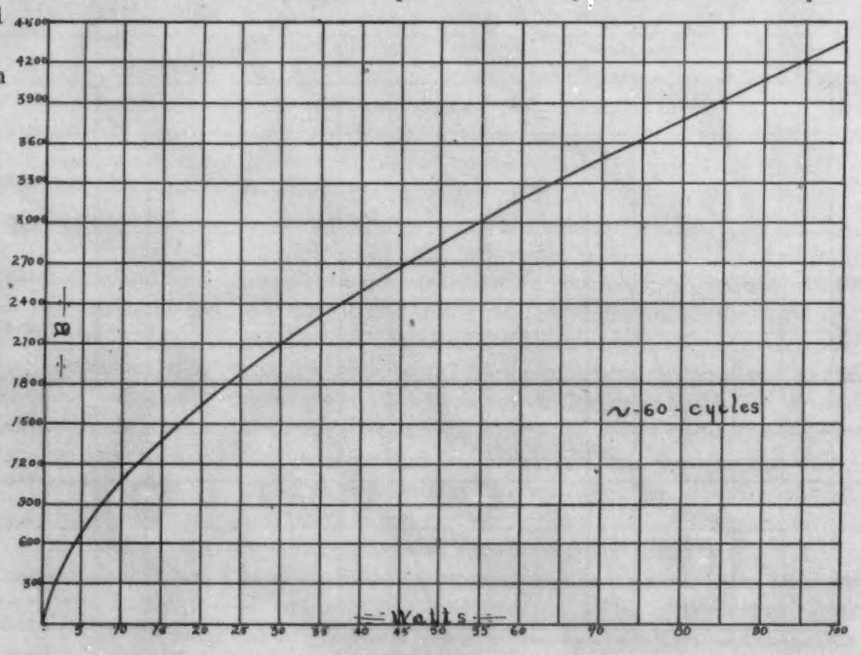


FIGURE 26

ity of the electromotive forces *EF*, *FG*, *GE* can be verified by means of a voltmeter. Their magnitudes depend on the ratios of transformation.

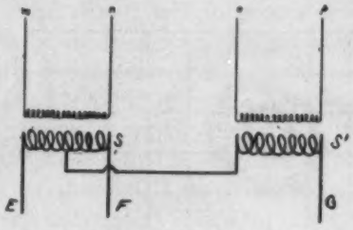


FIGURE 27

The instantaneous curves should be found for each of these circuits, and plotted as in Figures 29 and 30. Show that by interchanging the dynamo terminals to *o* and *p*, the curve of electromotive force is reversed. Draw the curves of induction *B* in each case and show that the direction of progression of the field is reversed. Similarly, interchange the terminals *F* and *G* and reverse the progression of the three-phased field.

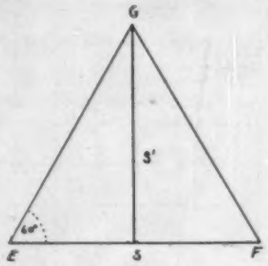


FIGURE 28

PART II.

SYNCHRONOUS MACHINES.

Synchronous machines are characterized by fields maintained constant by means of a continuous current from an exciter, and by armatures in which the alternating current is induced. The field poles may be surrounded by exciting coils and revolve, the armature being stationary; the armature may revolve, the field coils being stationary; or the iron of the field only may revolve, both exciting and armature coils remaining stationary as in the inductor type. In the first type, with magnetizing coils about each spool, the current delivered by them or to them will have a frequency equal to the product of the number of revolutions per second, and the number of pair of poles. In the inductor type the frequency equals the number of revolutions of the inductor per second, multiplied by the number of poles of the inductor.

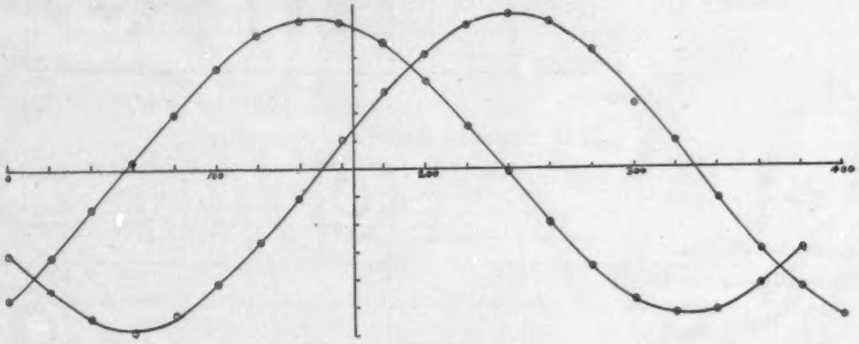


FIGURE 29

ALTERNATOR TESTS.

Each alternator test should be accompanied by a complete pescription of the purpose and character of the machine under test. Also, since the purpose of all testing is the determination of the mechanical and electrical fitness of the machine, for a particular purpose, and the verification of the constants employed in its design, it is essential that each test of a new machine be proceded by the calculated constants. Moreover, many of these must be known before the complete test of the machine can be worked out. For alternators, the following data concerning the design is desirable:

Volts (no load).
Volts (full load).
Amperes (100 per cent. power factor).
Kilowatts.
Frequency.

ARMRTURE DATA.

Type of winding.
Number of turns per circuit in series.
Number of circuits per phase.
Pitch of winding.
Size of conductor.
Number of ventilating ducts.
Amperes per square inch of conductor.
Resistance per circuit at 25 degrees C.
Number of coils.
Number of slots.
Number of slots per pole per phase.
Number of conductors per slot.
Diameter of armature. Peripheral speed.
Length of core over laminations.
Effective length of core.
Face diameter divided by the number of poles.
Pole pitch at armature face.
Dimensions of the slot.
Length of the air gap (minimum).
Length of the air gap (mean).
Length of pole arc.
Ratio of pole arc to pole pitch.
Armature flux at full load.
Density in the armature at full load.
Density in the teeth at full load.
Density in the pole face at full load.
Density in magnet core at full load.
Density in the magnet yoke at full load.
Leakage coefficient assumed.
Ampere turns to overcome armature reaction assumed.

FIELD WINDING.

Number of turns per spool.

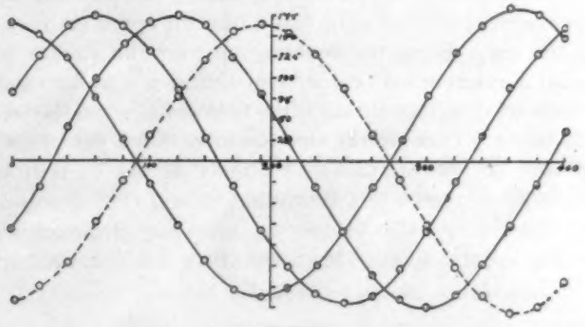


FIGURE 30

Size of conductor.
Number of conductors in multiple per spool.
Number of spools in series.
Total resistance at 20 degrees C.
Winding space.

MAGNETIZATION CURVE OF AN ALTERNATOR.

The total number of ampere turns required to force a given flux ϕ through the armature of an alternator is the sum of the ampere turns required for the various parts of the magnetic circuit.*

The flux through any component part of the magnetic circuit, making due allowance for leakage, divided by its cross-section gives its magnetic density, B. The ampere turns required per inch for the density B and for wrought iron, cast iron, cast steel and air, are given in Figure 19. Whence, knowing the cross-section, mean length and material of each part, the ampere turns for it are easily determined, and hence the total ampere turns for the flux ϕ in the armature. By assuming different values for ϕ and calculating the total ampere turns required, the magnetization curve can be predeteemined.

Now, the electromotive force induced per phase in the armature winding will depend on the number of lines cut ϕ, on the number of turns in series per phase T, on the frequency or rate of cutting, $\sim$ and on a constant depending on the winding.

$$\text{Or, } E = \frac{K \times \phi \times T \times \sim}{10^8}.$$

Kapp gives the following values for K:

Coil Width / Pole Pitch		1	⅔	½	⅓	1
Pole Arc / Pole Pitch	1	4	3.52	3.38	2.98	2.32
	⅔	4.92	4.62	4.26	3.58	2.98
	½	5.66	5	4.62	4.24	3.28
	⅓	6.82	....	....	....	....

If the ratio of coil width to pole pitch is taken as unity and if the ratio of pole arc to pole pitch is taken as $\frac{2}{\pi}$, the constant becomes 4.44 or $\sqrt{2} \times \pi$, and the electromotive force formula becomes as before given,

$$E = \frac{4.44 \times \phi + T \times \sim}{10^8}$$

Hence the relation of the induced electromotive force to the ampere turns is predetermined. It is called a saturation curve.

To determine it experimentally, bring the machine up to its rated speed and maintain a uniform speed throughout the test. Bring the field current from the exciter to its full maximum load value, then diminish it to zero and reverse its direction through the field coils, when the test may begin. Observe the electromotive force per phase, and the current in the field circuit as the current is gradually increased to a maximum value. The descending curve should also be taken, decreasing the exciting current. Care should be taken that the increase or decrease in the exciting current is continuous in order to avoid the effect of hysteresis. Results should be plotted as in Figure 31.*

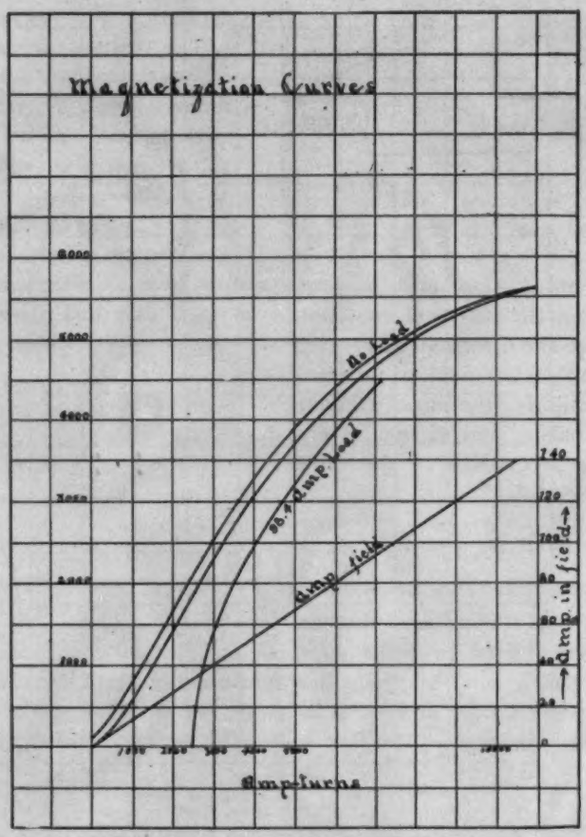


FIGURE 31.

The following log will be found useful:

Volts Arm.			Amperes Field	Ampere Turns Per Pole	Speed (Constant)
Phase No. 1	Phase No. 2	Phase No. 3			

SATURATION CURVE WITH FULL LOAD CURRENT IN THE ARMATURE.

The full load current of an alternator is the current which the alternator, working on a non-inductive external circuit, will give with the allowable temperature rise of the various parts. If the rating of the machine is K kilowatts, and the full load electromotive force between machine terminals per phase is V kilovolts, then the current will be in a

single-phase machine $C = \frac{K}{V}$

two-phase machine $C = \frac{K}{2V}$

three-phase machine $C = \frac{K}{\sqrt{2}}$

*Thompson's Dyn. Elec. Mach., 4th ed., page 181.

*Electrical World, Volume XXXVII, page 234.

The electromotive force at the terminals of an alternator when full load current is being delivered to an external circuit, will in general differ from the electromotive force on open circuit for the same excitation of the fields. In direct current dynamos, the terminal electromotive force is found to be the electromotive force on open circuit decreased by the ohmic "drop" due to armature resistance, by the drop due to the reaction of the armature on the field magnets, and by a small drop due to the self-induction in the short circuited coils. The terminal electromotive force of an alternator is reduced by the "drop" due to ohmic resistance, but may be decreased or increased by the armature reaction, and by the armature self-induction, depending on whether the current lags behind or leads the total induced electromotive force. Since both of these effects act together to decrease or increase the total induced electromotive force, Steinmetz combines them, and calls them the synchronous reactance.*

He shows that if

E_0 = total induced electromotive force,

x_0 = reaction of machine at synchronous speed.

r_0 = internal resistance

E = terminal electromotive force

then in polar co-ordinates

$Z_0 = r_0 - jx_0$ = the impedance of the machine at synchronous speed, and

$Z = r - jx$ is the external impedance for the same frequency. Then the current is

$$I = \frac{E_0}{Z + Z_0} = \frac{E_0}{\sqrt{(r + r_0)^2 + (x + x_0)^2}}$$

and the terminal voltage for given current I is

$$E = E_0 - I Z_0 = \frac{E_0 (r - j x)}{(r_0 + r) - j (x_0 + x)}$$

$$\text{or } E = \frac{E_0 \sqrt{r^2 + x^2}}{\sqrt{(r_0 + r)^2 + (x_0 + x)^2}}$$

For a non-inductive external circuit, x becomes $= 0$, and the terminal electromotive force becomes

$$E = \frac{E_0 r}{\sqrt{(r + r_0)^2 + (x_0 + x)^2}}$$

The last equation shows that the ratio of the terminal to the total electromotive force is the same as that between the external resistance and the total impedance.

The ratio between these two electromotive forces for a non-reactive external resistance is determined experimentally in the following manner:

Connect as in Figure 32. F is the field of the alternator M, and is supplied with current from the exciter x through the ammeter A, and the resistance R, besides the usual field box r. A_2 measures the current given by the alternator V through the water box WB, one being placed in each phase. Bring the machine up to speed, and pass full load current through a water box in each phase, the initial current through the field coils being adjusted so that the electromotive force is about 20 per cent. greater than normal electromotive force. Read volts, current through the fields and the speed. Next diminish the field current and readjust the armature current to normal value by means of the water boxes, and again read volts, current in the field, and the speed.

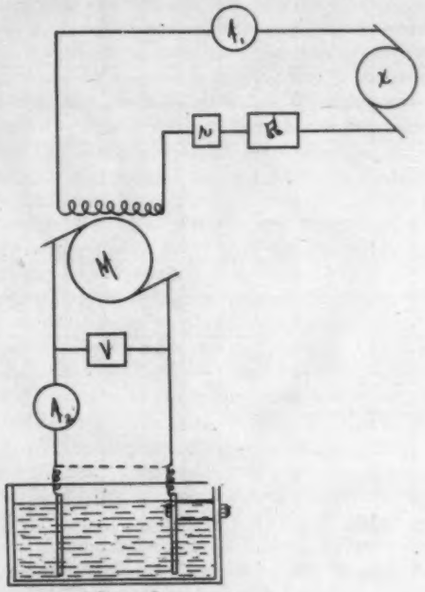


FIGURE 32

Results may be recorded in the following manner:

Volts—Armature Phase			Amperes—Armature Phase			Amperes Field	Ampere Turns Per Pole	Speed (Constant)
No. 1	No. 2	No. 3	No. 1	No. 2	No. 3			

Plot results as in Figure 31.

It will be seen that for zero external resistance and reactance, the terminal electromotive becomes zero, and the total induced electromotive force is used in overcoming the internal impedance. In the figure this electromotive force is 2000 volts, and 2400 ampere turns per pole on the field are required to produce it. If the internal resistance r_0 of the alternator is small compared with the reactance x_0, then

$$E_0 = E\sqrt{r^2 + x_0^2} = \sqrt{E^2 + E^2\left(\frac{x_0}{r}\right)^2}$$

and $\frac{x_0}{r}$ is the ratio of the reactive to the terminal volts. This relation is shown in Figure 31, where

$$\sqrt{\frac{\quad^2}{2000} + \frac{\quad^2}{4400}} = 4800 \text{ volts for the same}$$

excitation. The ampere turns required to overcome synchronous reactance volts is in this case 2400; this overcomes armature reaction and armature self-induction. The formula* for the armature reaction of a three-phase machine is $1.5 \times \sqrt{2} \times T \times I$, per phase per pole, where T is the number of turns per phase per pole and

*Phenomena, page 302.

*Elements, page 132.

is the current in the armature coil. In the particular case under consideration T was 8 turns per phase per pole and the current was 100 amperes, the connection being Y. The armature reaction per pole per phase is $1.5 \times \sqrt{2} \times 8 \times 100 = 1670$ ampere turns.

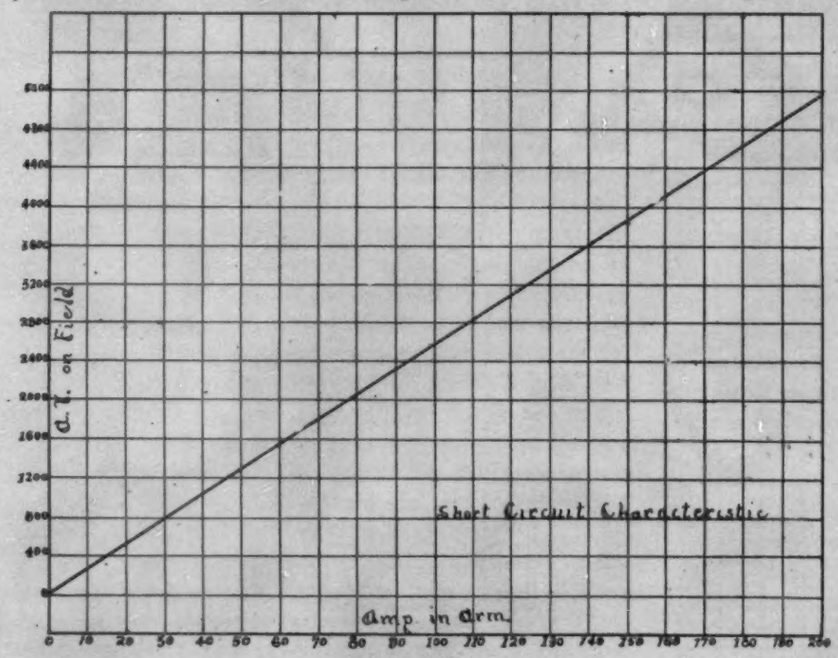


FIGURE 33

The difference 2400 — 1670 = 730 are the ampere turns to overcome the electromotive force due to self-induction, or $\omega L I$ approximated by means of the following formula:*

$$\omega L = K \frac{2\pi \times n^2 p \times l \times \left(\frac{b}{3a} + \frac{c}{a} + \frac{d}{2g}\right)}{10^8}$$

where n is the number of conductors per slot
p is the number of slots per phase per pole
l is the effective length of armature core.
a = width of slot
b = breadth of slot
c = thickness of wedge.
d = width of tooth
g = length of air gap

SHORT CIRCUIT CHARACTERISTIC.

The short circuit characteristic is a curve showing the relation between the current in the armature when the armature is short circuited through an ammeter or ammeters if the machine has several phases, and the ampere turns required to produce the armature current.

The alternator should be short circuited through a low resistance ammeter in each phase. Start the alternator with no current in the field, and bring it to its normal speed, maintaining the speed constant during the test. Introduce a large resistance in series with the exciting current at starting so as to prevent a large initial armature current. Observe the armature currents with increasing field currents. The machine will usually stand without injury 200 per cent. of full load current as a maximum value.

Record the results as follows:

Amperes	Armature	Ampere Field	Ampere Turns	Volts Armature (calculated from Saturation Curve)	Speed (Constant)

This curve shows the ampere turns required per pole in the field to overcome the effect of armature reaction, of armature self-induction, and armature resistance for various armature currents. It is usually a straight line.*

Instead of plotting ampere turns as in Figure 33, the electromotive forces corresponding to the ampere turns may be found from a curve similar to Figure 31 and plotted as in Figure 34.

This is called a synchronous impedance curve, since it shows a ratio of volts to current in the armature. That this impedance includes the armature reaction, and is not a true impedance, has already been mentioned. It will in general curve toward the X axis, depending on the degree of saturation of the magnetic circuit. The current

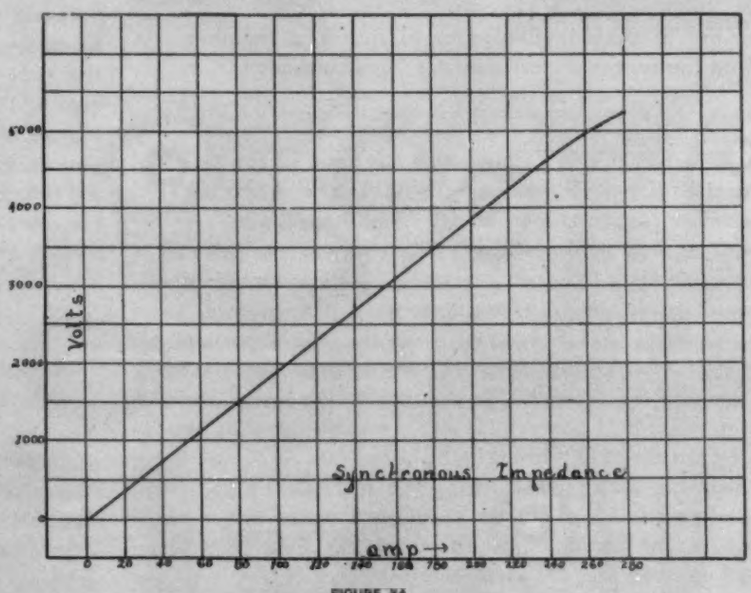


FIGURE 34

*Elements, page 19. Franklyn and Williamson, page 179.

*See *Electrical World and Engineer*, Volume XXXVII, page 234.

which would flow if the machine were accidentally short circuited with a given excitation for full non-inductive load current, and full load electromotive force be 6900, as in Figure 31. The open circuit electromotive force corresponding is 4750 volts. From Figure 34 the current which would flow through the short circuited armature with an applied electromotive force of 4750 is 246 amperes, or 2.5 times full load current.

Similarly, the current on short circuit for any other excitation may be found.

From this curve also may be found the "drop" in volts for any armature current. The ratio of this voltage for full load current to the rated full load voltage is called the impedance ratio of the alternator, and is used in calculating its regulation.*

(Continuation in next issue.)

OBITUARY.

William Chilton Clark, who was prominent in many electrical enterprises in various sections of the country from the time when nearly a quarter of a century ago he became interested with the Waterhouse brothers in the invention and exploitation of the Waterhouse Arc Lighting system, died at the home of his brother-in-law, H. A. Russell, in San Francisco, on February 28th last.

W. C. CLARK

W. C. Clark was born in St. Louis, Mo., in 1852. He was of good Kentucky stock, his father being Robert Clark, who presided at the Sacramento bar up to the time of his death, and his grandfather being James Clark, a former governor of Kentucky, and for whom Clark County of that State is named. The early business experience of him whose death is now mourned began as a clerk in the Sacramento office of Wells, Fargo & Company's express. Later he was connected with the Central Pacific Railroad Company, when its main offices were at Sacramento, and afterwards he became a teller in the bank of D. O. Mills & Co., of that city. He was married to Miss Sallie Russell, in Sacramento, on February 25, 1875, and shortly thereafter moved to San Francisco to accept the cashiership of the well known hardware firm of Carolan, Cory & Co.

In the early days of electricity, when arc lighting prevailed practically alone, Mr. Clark became interested, as stated, in the Waterhouse Arc Lighting system to the extent of becoming manager of the Waterhouse Electric Company. Old timers remember well of the success achieved by the Waterhouse system of third brush regulation in arc lighting, and so pronounced did its success become that it attracted the attention of the Westinghouse Electric Company which bought up the entire property and patents of the Waterhouse Electric Company in 1889, whereupon Mr. Clark was made district manager of the San Francisco office of the Westinghouse Electric Company. This placed the entire interests of that concern for the Pacific Coast in his hands, these interests consisting of the exploitation and sale of Westinghouse single-phase alternating current dynamos, Waterhouse direct current arc lamps and dynamos, and United States direct current incandescent electric lighting dynamos. He continued in this position until the early '90s, when the financial adversities of the parent company enforced extreme economies, one of which was the abandonment of the San Francisco office. Mr. Clark was then called to Pittsburg, soon after which a reorganization of Westinghouse affairs was affected, the name of the company was changed to the Westinghouse Electric and Manufacturing Company, and Mr. Clark was made assistant treasurer and general manager of the new concern. He held this position during the strenuous times of 1892-93 and by an exemplary devotion to the interests intrusted in his care did much to give the Westinghouse Electric and Manufacturing Company that firm foundation upon which has been based the financial structure and business policy of its magnificent business of today. In 1895, however, the rigors of the climate of the East compelled him to return to California on account of failing health. He located in San Francisco, and interested himself in the Union Scale and Manufacturing Company, where he remained until death.

While handling the Westinghouse interests in San Francisco, prior to the discontinuance of their local offices, Mr. Clark did considerable pioneering work worthy of record. In the early '80s he sold the first electric lighting plant ever installed in China. This was the Westinghouse equipment that was installed by the Canton Electric Light Company, in Canton, China, under the direction of G. A. Wiese, formerly city electrician of the Alameda Electric Light Works, of Alameda, Cal. In 1889 Mr. Clark sold and installed the electric lighting plant now being operated on the Ferryboat "Piedmont," running between San Francisco and Oakland, the installation consisting of a United States incandescant dynamo having a capaciiy of 316 candle power lamps. About the same time the Sacramento Electric Light Company was organized by Mr. Clark, together with Jos. D. Redding, H. A. Russell and others. Westinghouse apparatus was used throughout, but later the plant was merged with that of the Capitol Gas Company. Further pioneering electric work was done by Mr. Clark, albeit in a different direction, by the installation of the first acetylene gas plants ever erected in New Zealand and Australia. This was in 1895.

Mr. Clark's loss is mourned by the entire electrical fraternity, for his life was pre-eminently marked by his affability and a uniform courtesy and straightforwardness in all his dealings. His Kentucky breeding and early training was ever apparent in his courtly manner, and he was a gentleman indeed, in every sense of the word. A wife and two daughters mourn his loss.

Ira Bishop, one of the best known business men of San Francisco and who was prominent in its early central station history as well as in the development of the Piedmont street railway system of Oakland, died on February 21st. In May last he was stricken with paralysis, from which he never recovered, although able to be upon the street. Incessantly his head pained him greatly so that, racked and despondent, he sought surcease in death by his own hand in Golden Gate Park.

Mr. Bishop was a native of Bishop's Mills, Canada. He was born April 13, 1846, and attended school until he was fourteen years of age when he entered the employ of his father, who owned large saw and lumber mills, as salesman and bookkeeper. At seventeen his restless spirit took him into the United States and finally he secured employment at Sheboygan, Mich., where his industry earned him more money than any other employee. Tiring of the lumbering business, he next turned his steps to California and reached Truckee in June, 1871, where he engaged in various enterprises in Boca and vicinity, among others being the construction of a bridge across the Truckee river. Then he accepted an offer from C. C. Comstock, superintendent of construction of bridges of the Central Pacific Railroad Company, with whom Mr. Bishop established a reputation that led him in 1880 to accept a more lucrative position with the firm of Balfour, Guthrie & Co., of San Francisco. Completing his contract, he superintended the erection of the Benicia Agricultural Works for Baker & Hamilton of this city, and also built a hotel close to the workshops. Later he constructed a wharf and grainhouse for the Grangers' Business Association and then built a ferry slip connecting Benicia with

*See Article 79 of Standardizing Committee, American Institute of Electrical Engineers.

Martinez, and a cannery and wharf for the Carquinez Packing Company. Soon thereafter he built the Nevada docks near Port Costa for the late James C. Flood, as well as a grain warehouse at Hanford. In the meantime he improved the sack elevator in ordinary use. In 1885 he was employed by the San Francisco Tool Company (which was practically the forerunner of the present great firm of Chas. C. Moore & Co., Engineers, Inc.), bought an interest therein and was elected a director, and during the following year he was appointed superintendent of the Pacific Power Company.

It was during his management of the properties last named that Mr. Bishop became interested in electric power distribution. Originally the Power Company distributed power by lines of countershafting which extended underground throughout its own block and across First Street to that which adjoined on the east. In order to reach districts outside of these two blocks, the then venturesome use of electric power was resorted to in 1897. The first electrical apparatus installed was designed and built by Dr. N. S. Keith, then of San Francisco, and who was the founder of the American Institute of Electrical Engineers. This pioneer installation consisted of four forty-horsepower, horizontal field, bipolar dynamos with armatures paralleling the axes of the fields. They were of a simple shunt wound, constant current type, having an output of approximately fifteen ampères. The field was regulated by cutting more or less of 100-volt incandescent lamps in or out of the field circuit and the constant attention of a switchboard attendant was required to keep the amperage at, or rather near normal, for, with the plain series motors used, the throwing off of five or ten horsepower by a consumer worked the ammeter needle into a frenzy. Housetop distribution was used, with underwriters wire, and while in the light of present knowledge the plant was primitive and its efficiencies had perhaps better not be discussed, nevertheless it gave profitable service for years. In 1894 the venerable old plant was relegated to the scrap pile and an underground system was installed under the specifications and supervision of Messrs. Sidney Sprout and Geo. P. Low, then practicing as electrical engineers under the firm name of Low & Sprout. This system was gradually developed until it covered some twenty odd blocks in the principal manufacturing center of the city, and at the time of its installation it was regarded as being the most efficient electric power distribution plant in the West. Its affairs were administered under Mr. Bishop's management and in an article appearing in these columns in 1897* the achievements which he attained in the internal administration of the affairs of the Power Company were discussed in these words:

The Pacific Power Company, through the able superintendence of Ira Bishop, has won the reputation of being able to get more power out of a ton of coal than any other steam power producer on the Pacific Coast. Indeed, the attaining of this distinction seems to have been his ambition, with the result that there is probably not to be found west of the Rockies a concern which has given longer years of more patient study and experimenting, or which has made such exhaustive and elaborate tests, or has followed to the most minute detail every item of the cost of power, or has for years required such exacting reports from employees, than has the Pacific Power Company. No item of expense has ever been too small for searching scrutiny; no cost of experimenting or test has ever been a deterrent from ascertaining the facts regarding any feature forming a factor of the cost of steam power. A number of years ago it built at great expense a pipe line through which it pumps condensing water from the bay; for years it has weighed every pound of water going through the boilers and every ounce of coal burned, and it was the first concern on the Pacific Coast to buy coal by the amount of water evaporated and to saddle upon the coal dealer the "personal equation" of the fireman. It will not be doubted, therefore, that the Pacific Power Company has reduced the science of central station economics to to a fine art.

Coincident with the development of the Pacific Power Company came the orginization and building of the Piedmont Cable Railway system extending from Washington and Seventh streets, in Oakland, to Piedmont Heights. This was done by Mr. Bishop and his associates in face of the opposition of the Market Street Railway Company, of San Francisco, which professed to control all patents under which a cable railway could be built. Through Mr. Bishop's ingenuity these patents were successfully evaded, the road was installed and operated with the greatest success for a number of years, and when, at last, electric traction demonstrated its general superiority and in particular its ability to surmount the steep grades of the Piedmont Hills, which ranged as high as 14 per cent., Mr. Bishop promptly changed the system from cable to electric traction. Both systems were operated from the Piedmont power house, adjoining which he and his associates also built the well known Piedmont Baths.

Unfortunately, Mr. Bishop engaged in speculation some years ago, which depreciated his fortune that was at one time quite large, but despite this reverse he left a comfortable estate to his bereaved widow. At the time of his death he was Pacific Coast representative of Falk & Co., as well as selling agent for the Pacific Jupiter Steel Company, besides being principal owner of the Bishop-Wilbur Company.

*THE JOURNAL Volume, IV, page 38, June, 1897.

Burr Bassell, the well known civil engineer of Los Angeles, and whose specialty in the line of hydraulic work and dam construction, has made his name very familiar in electrical transmission development throughout California, died suddenly at his home in Highland Park, on February 25th, from an acute attack of spinal meningetis. A wife and daughter and friends in legion will ever mourn his untimely death.

Mr. Bassell was born in West Virginia in 1858, and came to California in 1887, locating in Los Angeles, where for some time he was associated with Henry Dockweiler as assistant city engineer. He was connected with a number of important engineering undertakings in various portions of southern California, noteable among which are the Arrowhead Springs Company and the Kern River Company, which he has been serving for the last three years as consulting engineer in building its now practically completed Kern River plant. In central California his principal work consisted in building the Tabaud dam of the Electra (Standard) plant of the California Gas and Electric Corporation, which is the largest and most important earth-fill dam in California, if not in the West. He was the author of an invaluable book entitled "Earthwork Dams," just published by the Engineering News Company, and was also a contributor to various scientific publications. It was but recently that Mr. Bassell returned from a three months' visit in the East, and where he received the appointment as chief engineer for the $2,000,000 hydraulic dam construction enterprise at Wichita Falls, Tex.

THE COST OF GAS POWER.

A RECENT paper read by Hugh Campbell before the Leeds Local Section of Electrical Engineers of Great Britain, on gas engines for central stations, gives some very interesting figures for two stations in Guernsey, which are owned and operated by the same company—one being a steam driven station and the other being driven by gas engines. A very accurate comparison of the cost of producing a unit of current in these two stations is therefore possible. The figures which Mr. Campbell quotes show for every month a considerable saving in works cost per unit generated in favor of the gas-driven plant. The unit generated is taken as the standard basis of comparison in order to eliminate the loss due to transforming and transmitting the current. For the month of October the works cost per unit generated is .7 of a cent for the gas-driven station and about 1 cent for the steam-driven station.

Edward F. Cannon, formerly general manager of the Northwest Electrical Engineering Company, of Portland, Or., and who retired therefrom November last, has established the engineering and contracting firm of Edward F. Cannon & Co., with headquarters in the McKay Block, Portland. The new concern will operate throughout Oregon, Washington and Idaho in railway, light, power and hydraulic development.

INDUSTRIAL

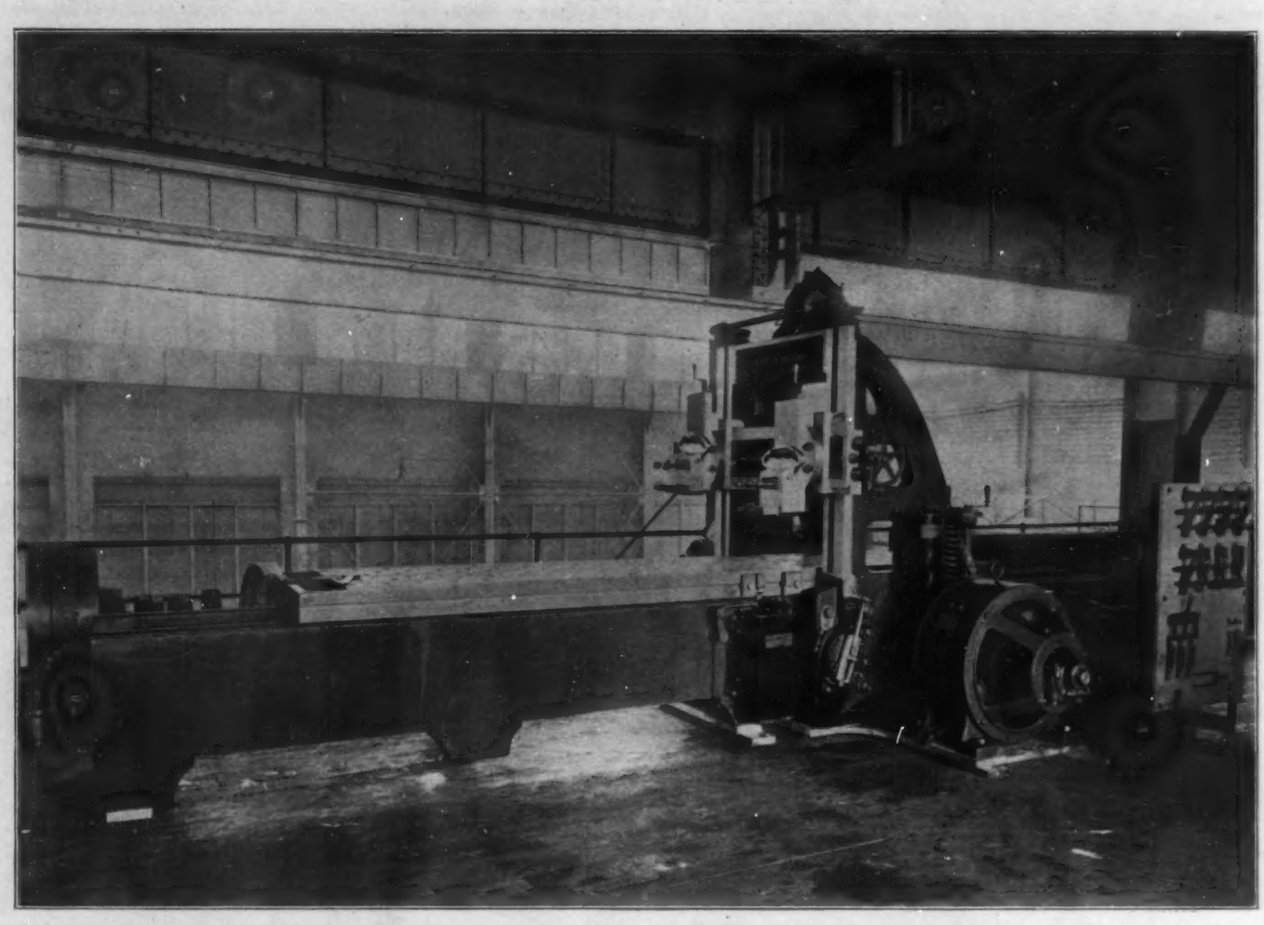
AN IMPROVED DIRECT CONNECTED VARIABLE SPEED MOTOR DRIVE FOR PLANERS.

WHEN the modern high power tool steels were put upon the market it soon became evident that all classes of machine tools must be made heavier and stronger if advantage was to be taken of the heavier cuts at faster speeds thus made possible.

The lathe was the first tool taken up by most builders, and by means of combinations of back gears a great range of speeds was obtained. There are, however, many jobs, such as the facing of piston heads, flange couplings, etc., where a given revolutions per minute gives a high cutting speed at the periphery but an exceedingly slow cutting speed when nearing the center, making it desirable to be able to change speed at will without stopping the lathe, as this invariably leaves a mark on the work. Another and more important reason for wishing to change speed without stopping is that no operator can judge accurately just what cutting speed the tool will stand before starting, so it is desirable to be able to start slowly and increase to the maximum that tool and machine will stand.

The individual direct motor drive with a controller giving speed variation by means of field and armature resistance was applied with greater success than any of the various mechanical devices. This drive was simplified and perfected by the development of the variable speed motor giving the whole range of speeds necessary, with full rate horsepower throughout, without the use of any change gears. It has been used with perfect success for the lathe, boring, mill, drill, press, milling machine and small shaper, but with less success for planers and large shapers, for here it is necessary to provide for reversal.

There are a number of belt drives built using motors and mechanical change speed clutch devices, intermediate speed variations being obtained by motor control. A heavy pulley or flywheel is used to furnish the extra power required at reversal. The motor is usually mounted on top of the housing, which necessitates the belts running vertically, and therefore very tight. The slippage, inevitable with heavy work at high speeds, and the constant reversals, are ruinous to belts, so that it is not possible to take full advantage of the cuts and speeds which the modern tool steels will stand. Constant speed motors with mechanical, hydraulic or magnetic friction clutches for reversing and change gears for varying the cutting speed have been used with some success, especially for the smaller sizes. At best, however, these devices give but a few set speeds, and as the clutch can transmit its full rated power only at the speed for which it was designed, no variation by means of motor control is possible. It requires some time to change the gears, and then perhaps the operator must use the lowest speed because the tool will not quite stand the next step.



AN IMPROVED DIRECT CONNECTED VARIABLE SPEED MOTOR DRIVE FOR PLANERS

It is evident that to get maximum output from a planer, as from other tools, we must have a wide range of cutting speeds in small steps from the lowest to the highest. This has been

complished by gearing a variable speed motor direct to the driving shaft, and by means of a reversing switch, operated by dogs adjustably mounted on the platen of the planer, working in conjunction with a set of stopping and accelerating switches, the motion of the motor is reversed at either end of the stroke. The operation of the controller is such that the driving motor will reverse and accelerate the platen of the planer just as rapidly as is consistent with the power of the motor. The maximum current which can flow to the motor is absolutely limited, so that there is no sparking or undue mechanical straining at the instant of reversal.

The speed controller is provided with a marked dial showing the cutting speed. To obtain the desired speed it is simply necessary to turn the handle to the proper notch, and this can be changed at will without stopping the planer if it is desired to increase or decrease the speed. A similar speed controller for the return stroke is provided if desired. Cut and return stroke speeds are entirely independent.

The platen may be reversed by hand for setting up work and for adjusting the dogs for proper length of stroke. A shifter lever attached to the reversing switch is used for this purpose, and the operator can stop the planer instantly by putting it in the central position. This shifter motion is carried to the far side of the table as in usual for belted planers, so that any machinist accustomed to operating a belted planer can operate a planer equipped with this drive without further instruction. The accelerating controller is automatic and requires no attention whatever from the operator.

The Electric Controller and Supply Company, of Cleveland, Ohio, which holds the patents and has placed this drive upon the market, tested it thoroughly on a planer doing regular commercial work before equipping a thirty-six-inch by thirty-six-inch by twelve-feet Pond planer which has been successfully demonstrating its practicability and great superiority over all other planer drives at the St. Louis World's Fair and for which the company was awarded a gold medal. The cut is from a photograph of this installation, and shows the motor geared to the cross shaft, the accelerating board just beyond the motor, a small speed controller on the housing convenient to the operator and the reversing switch with its shifter handle actuated by the dogs on the platen. Variations of cutting speed through a range of two and one-half to one are obtained with single voltage direct current, and of five to one with two voltage direct current, with corresponding ratios for the various multi-voltage systems.

The drive can be applied to any planer, old or new, does away with all belts or clutches and will undoubtedly make possible increased output of from 50 to 200 per cent. over the regular belt driven planer.

RECENT DOBLE WATER WHEEL SALES.

A SUBSTANTIAL and increasing business in tangential water wheels, particularly in large units, is reported by The Abner Doble Company, of San Francisco, the percentage increase in horsepower of wheels sold by the company in 1904 over 1903 being 116 per cent. Among orders recently taken are the following: For the Electra plant of the Standard Electric System the company is now building three 7500 horsepower Doble water wheels, each being of the same general design and capacity as the Doble wheel installed during the last year in the de Sabla plant of the California Gas and Electric Corporation, and which has repeatedly developed 8000 horsepower on overload. One of the large Electra units will operate under a 1250-foot head at 400 revolutions per minute, the water being delivered through a seven-inch nozzle. The other two 7500 horsepower wheels will be directly connected to one 4000-kilowatt generator, forming a double unit for utilizing water from two separate sources under different heads. The design of this unit is an unusual one, inasmuch as each wheel has sufficient capacity to drive the generator at full load. One of the wheels will be driven by a six-inch jet under a head of 1465 feet, the water being taken directly from the main gravity conduit. The other wheel is to be driven by a seven-inch jet under a head of 1250 feet, the source of supply being a large reservoir at the end of the main conduit. This arrangement permits the operation of the generator at full load by running either wheel at its full capacity or by running both wheels under partial load, according to the conditions of the water supply. These operating conditions are only made possible by the use of Doble needle regulating nozzles which regulate the quantity of water delivered to each wheel. The speed of all three Electra wheels is unusually high, considering the size of the machines, but is permitted by the use of specially designed Doble bearings, similar to those so successfully introduced in the large de Sabla wheel. Each of the three Electra wheels will be operated from a Doble needle regulating and deflecting nozzle, the deflecting element in each case being controlled by a suitable hydraulic governor. A 200 horsepower Doble exciter wheel to operate under a head of 1465 feet at 720 revolutions per minute will also be furnished for the Electra plant.

Two 800 horsepower Doble main unit wheels and two forty horsepower Doble exciter wheels have been built for the new Santa Ana No. 2 plant of the Edison Electric Company, of Los Angeles. These wheels will operate under a head of 305 feet, the speed of the 800 horsepower wheels being 176 revolutions per minute. Two seventy-five horsepower Doble exciter wheels have been built for the Pike's Peak Hydro-Electric Company, of Colorado, to operate at a speed of 975 revolutions per minute under a head of 2100 feet, the highest in the United States. A 300 horsepower double Doble wheel equipped with two Doble needle regulating nozzles has been ordered by the Hilo Electric Light Company, of Hawaii. For the Nevada City plant of the California Gas and Electric Corporation, three 570 horsepower Doble wheels have been supplied to operate under a head of 190 feet. The California Fish Commission ordered a Doble wheel to work under the low head of twenty-three feet. The Braden Copper Company, of Chile, has ordered four 340 horsepower Doble wheels for operation under 930 feet head, three for belt drive and one for direct connection to an electric generator. Doble twelve-inch laboratory water motors have been built for the University of Illinois, and the University of Texas. An interesting order recently received calls for a complete sawmill outfit to be installed in the Phillipine Islands, the machinery to consist of a Doble water wheel operating under 400 feet head and directly connected to the mill. The order included the sawmill as well as the riveted steel pipe for the pipe line.

AN AUTOMATIC ELECTRIC PUMP AND RECEIVER.

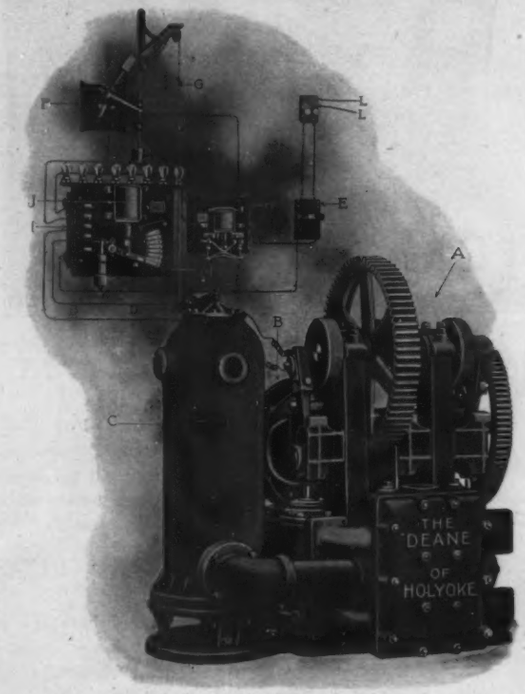
THE illustration shows a motor-driven, triplex, boiler feed pump and receiver with automatic switches and motor starter for automatically draining heating systems and factory apparatus that depend upon a free circulation of steam for their efficiency. By doing this it serves a double purpose: First, it automatically relieves the system of the water of condensation constantly collecting therein, thus insuring a free and unobstructed circulation and incidentally preventing snapping and hammering in the piping, which is in many cases due to entrained water; and, secondly, it automatically delivers this water directly to the boilers without the intervention of tanks or other commonly used devices. Not only does it relieve the system of a troublesome factor, but it introduces a supply of feed water into the boiler at a temperature impossible otherwise without the use of a special water heater. In modern hotels and apartment houses there is a great demand that machinery should operate with the least possible noise. One of the greatest annoyances is water hammer in the pipes reaching to every part of the building, but by the use of this pumping outfit such noise is entirely eliminated.

Electric pumps can be installed in locations to which it is impossible to carry any other motive power, and as this pump, by reason of its automatic control, runs only when occasion demands, no special attendance is necessary and the total cost of operation is for current actually used.

The following description will make the action of the apparatus plain: *A* is the pump, *B* the motor, *C* the receiver and *D* a lever, operated by a pail float within the receiver, which rises and falls as the water level changes. *E* is the main-line switch, which operates by hand and is used to cut out the line when necessary. *F* is a switch operated by the float in the receiver through the chain and counter-weight *G*. *H* is the automatic switch which admits current to the motor starter *I* when the switch *F* is thrown in by action of the float. *I* is the motor starter which delivers current gradually to the motor and is operated through the solenoid *J*. *K* is the fuse block and *L* the line wires.

The switch *E* being closed, water in the receiver rises and throws in the float switch *F*, thereby turning the current through the automatic switch *H*, which in turn delivers it to the solenoid *J*, thus gradually pulling up the lever *I* and gently starting the pump. As the water is pumped out and the float falls, the operation is reversed and the pump stops.

The cut shows the standard type of double-acting pump and receiver with electrical connections and motor, as usually installed. The pump may be either single-acting or double-acting

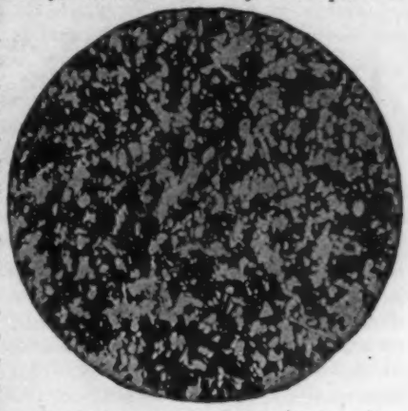


STANDARD TYPE OF DOUBLE ACTING PUMP

as desired, the arrangement in either case being the same. The receiver is of the vertical form and consists of a cylindrical closed chamber or tank mounted on a bed plate secured to the base of the pump, so that the apparatus is compact and self-contained. An opening at the bottom of the receiver is provided with a pipe connection to the suction of the pump and the water of condensation flows into the receiver through the inlets shown near the top. Three separate inlets are provided for convenience in connecting the returns. The receiver float is of a patented type and is a simple pail open at the top and hung from a lever having a counterweight so placed as to overbalance the weight of the pail. The pail is kept filled with water and when the receiver is empty the weight of this water causes the pail to hang in its lowest position. As soon as the water rises in the receiver above the pail the weight of the float is immediately reduced to the mere weight of the pail and the counterweight causes the pail to rise to its highest position and to throw the float switch *F* to start the pump. This style of float is very simple in construction, sensitive in operation and has none of the objectionable features of the closed or ball float. The float is so guided as to hang in the center of the receiver without swinging and the receiver inlets are provided with hoods to prevent the entering water from interfering with the action of the float.

THE THEORY OF GRAPHITE LUBRICATION.

THE resistance to free motion offered by surfaces in contact is called friction. It is due solely to the roughness and unevenness of the surfaces in contact. Whereas it may be possible to produce what appears to the unaided eye as "a perfectly smooth surface" on metal, an examination under a powerful lens or microscope will invariably reveal a very different condition of affairs. When so magnified some metals appear granular, some lumpy, some crystalline in a variety of shapes and some quite fibrous. The illustration herewith shows a small area of an ordinary smooth "babbitted" surface, greatly magnified, emphasizing the major premise that "a perfectly smooth metal surface exists only in theory or imagination."



PHOTOGRAPH OF BABBITT METAL (MAGNIFIED)

When two metal surfaces are brought into sliding contact these minute elevations and depressions interlock and resist free motion, the greater the pressure, the greater the resistance. If force be applied to surfaces thus in contact the irregularities of the surfaces must ride over one another or the minute projections be broken off. When this occurs there is continual abrasion and all of the energy thus absorbed is converted into heat.

Lubrication consists in separating the bearing surfaces by a layer of some other material, in machinery commonly an oil or grease thick enough to prevent the minute irregularities from even touching. The thicker or more viscous the lubricant, the thicker film will it form; but also the more viscous the lubricant the greater its own "internal friction." Oils and greases must not be too thick, especially where the speeds are high. It is a safe rule to follow to use the thinnest oil or grease that will keep the surfaces apart and keep the bearing cool.

A cardinal principle in lubrication, evident from the above is: "The smoother bearing surfaces can be made the less friction will be encountered and the easier will they be to lubricate."

This principle is emphasized by the action of flake graphite in filling up the minute depressions, roughnesses, and pores in metal surfaces, bringing them much nearer to a condition of perfect smoothness, which brings about a very great reduction in the "solid friction" between those surfaces. Graphite, with its strong tendency to attach itself to metallic surfaces, imparts a veneer of marvelous smoothness and great endurance that materially reduces the necessity of a thick oil film and effects a double reduction in friction.

This will be most readily understood from a glance at the following diagrams, which picture in exaggerated degree the condition of every bearing surface:

Fig. 1

Fig. 2.

Figure 1 shows ordinary friction surfaces, separated by a comparatively thick film of oil, while Figure 2 illustrates the manner in which graphite overlays the roughnesses, making a surface of exceeding smoothness that allows the use of a thinner lubricating layer.

Thus, in a word, the lubricating effect of graphite is to provide so perfect a surface that the oil film may be thinner and of thinner oil. Hence there is an apparent and logical reason for believing that flake graphite will reduce friction.

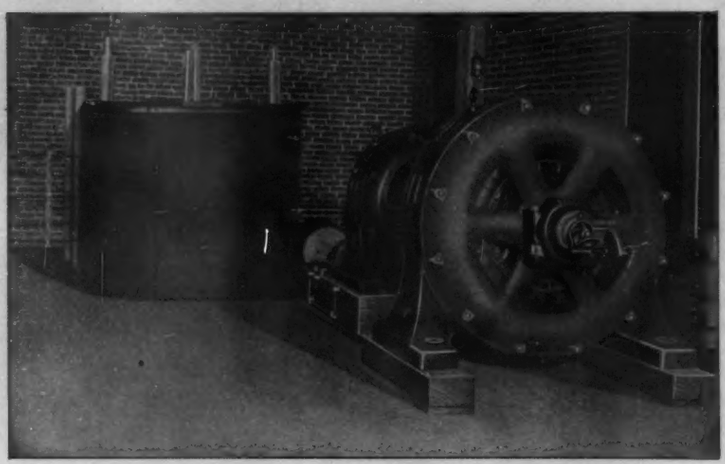
Graphite attacks friction at its cause, whereas oils and greases are simply make-shifts to keep relatively rough surfaces apart, and that, in most cases, only indifferently well. It is when flake graphite and oils and greases are used together—the graphite to perfect the surfaces, the oils to provide the separating layer—that, in general, the best results are to be obtained.

A HIGH POTENTIAL LABORATORY.

THE Locke Insulator Manufacturing Company has recently added to its equipment a laboratory for electrical and electro-chemical research along the special lines required for a positive and accurate development of high potential insulators, it being the intention to make a more thorough study than has before been attempted of insulating materials for extremely high potentials and of insulator design.

The laboratory is full fire-proof construction measuring twenty feet by forty-eight feet in size. The foundations and floor are of heavy concrete, designed to carry the heavy machinery without communicating vibrations to any delicate apparatus. The electrical equipment includes a transformer with a guaranteed capacity of 200 kilowatts at 300,000 volts. It is of the core type, with approximately ten inches by ten inches cross section of iron and has a primary wound for 1100 volts, made up of four wires in parallel, allowing of some flexibility in connection. The secondary consists of approximately forty-two miles of No. 26 wire, which, under oil, will carry 100 per cent. overload for considerable periods of time and at an overload potential of 400,000 volts this transformer is by far the most powerful electrical testing equipment in present use. The secondary winding is divided into two parts, which can be connected in parallel or series, giving full loads at low potentials.

Current for the primary of the transformer is provided by a motor-generator set, power for which is obtained from a local



HIGH VOLTAGE TRANSFORMER AND MOTOR-GENERATOR SET

transmission line. The set consists of a 440-volt, three-phase, twenty-five-cycle, 200-kilowatt induction motor, direct-connected by flexible coupling to a sixty-cycle, 1100-volt, single-phase generator of similar capacity. For purposes of experimentation or for special commercial test requirements, higher or lower frequency is obtained by belt connection, using various sizes of pulleys. The controlling switches for the generating set are located on a slate board placed so that the operator can overlook any test being carried on in the commercial testing room nearby. Ordinary controlling switches and rheostats together with instruments are located on this board.

To facilitate measurements of secondary voltages a spark gap, adjustable by hand, is provided with a scale calibrated to 480,000

NO. 807 INSULATOR, ON METAL PIN AND CROSS-ARM, ARCING TO CROSS-ARM AT 40,000 VOLTS, UNDER RAIN TEST. PRECIPITATION 3-4 INCHES PER MINUTE

volts, enabling test of any material to be made. For more accurate measurement of the high voltages a secondary voltmeter has been installed. This instrument, submerged in oil, transfers its readings by means of a mirror to a calibrated scale, which is read by means of a telescope. The very small secondary currents are measured by means of an inclined coil instrument inserted at the point of earth potential of the secondary winding.

Extending some distance from the laboratory is an experimental pole line of standard poles and cross-arms adapted to receive any style of pins or insulators, whose distances apart may be varied.

A simple form of dynamometer provides facilities for the testing of tensile and crushing strength of insulators and insulating materials. In order to study very refractory substances an electric furnace, capable of absorbing 200 kilowatts, is provided, forthe ceramic and electrical development of insulator design and manufacturing are so closely allied that the two lines of investigation are maintained in close co-operation.

The lack of a definite understanding of the methods of testing insulators and high voltage porcelain by some of the users or prospective users of this material, has prompted the Locke Insulator Manufacturing Company, in its recent catalogue No. 8, entitled "The Insulator Book," to describe the several plans employed, which are as follows:

The standard duration of all tests is one-half minute at full potential.

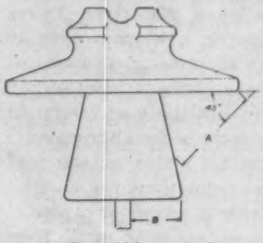
Method A is the usual method of test for either one piece or multi-part insulators. The plan consists in immersing the head of the insulator in water up to the middle of the side wire groove and filling the pinhole with water to the depth of the threading.

The connections are made as illustrated. Insulators shipped "knocked down" are tested with the parts assembled in proper relationship; insulators shipped cemented are tested after cementing.

Method B is a special test for multi-part insulators and consists in separately testing each piece, exactly the same as the whole is tested in Method A.

Method C is a dry test and is a test of the whole insulator, whether one piece or multi-part.

Special shapes often necessitate special applications of these methods and below is given the manner of applying tests for products varying in form from ordinary insulators. The voltage is always applied at points of strain under actual use.



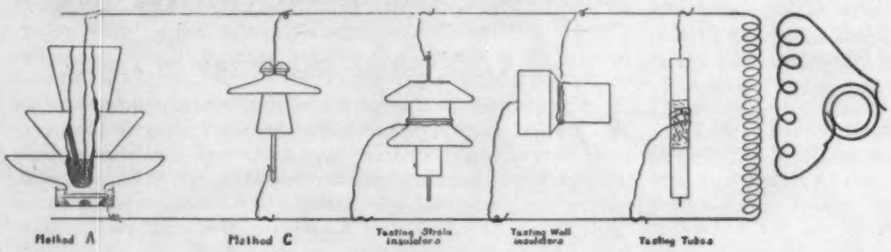
A + B = 4½-in. = Arcing Distance Wet

Strain insulators are tested (Method C) by using a metal tube passed through the insulator as one terminal and a chain or wire around the wire groove as the other terminal. Special strain insulators are tested by applying voltage between top and bottom castings.

Wall insulators are tested (Method C) by passing a metal rod through the insulator and applying a metal strap around the outside at the point provided for the panel.

Straight tubes are wrapped at their middle with tin foil for one-third their lengths and passing a metal rod through the holes (Method C).

The wet sparking distance is obtained as per the accompanying illustration, which shows the method of measuring distance on a Locke No. 408A insulator. The conditions assumed for these measurements are: The pin is one inch in diameter at the bottom of the insulator and high enough so that the spark will jump to the pin and not to the cross-arm, except for strain insulators, which are measured from the edge of the lower petticoat vertically to the cross-arm. The angle of precipitation is 45 degrees from the vertical.



Below is given a table of sparking distances in air between sharp needle points, as employed in testing.

Kilovolts.	Inches.	Kilovolts.	Inches.
5	0.225	90	8.35
10	.47	100	9 60
15	.725	110	10.75
20	1.00	120	11.85
25	1.30	130	12.95
30	1.625	140	13.95
35	2.00	150	15.00
40	2.45	175	17.80
45	2.95	200	20.50
50	3 55	250	25.60
60	4.65	300	31.00
70	5.85	350	36.10
80	7.10	400	41.20

Two important catalogue price lists have recently been issued by The Electric Storage Battery Company namely, "Price List A. 1905, Fifth Edition, pertaining to all types and sizes of Chloride Accumulators," and "Price List X. 1905, Sixth Edition, pertaining to all types and sizes of Exidi Batteries for electric vehicles." They are replete with data.

THE LARGEST CENTRIFUGAL PUMP EVER BUILT.

A RECENT product of the Byron Jackson Machine Works, of San Francisco, is noteworthy as being the largest and in many respects the most extraordinary piece of pumping machinery ever turned out in any shop of this or any other country. It consists of a high head centrifugal pump built for the purpose of delivering the necessary water to a battery of hydraulic giants operating on the gravel deposits of a large mining company in Oregon.

The pump is of the five-step series type operating under a maximum pressure of 250 pounds per square inch, which is equivalent to a total lift of 580 feet. Its capacity under normal conditions is 9000 gallons of water per minute, and it is driven by four 400 horsepower turbine water wheels with which it is in direct connection.

HIGH GRADE CALIFORNIA-MADE DRY BATTERIES.

A NEW electrical manufacturing industry has been instituted in San Francisco through the organization of the Pacific Carbon and Battery Company, consisting of the consolidation of The Los Angeles Electrical Specialty Company and the Ecco Battery Company, of San Francisco, by local capitalists, prominent among whom are W. L. Hughson and Geo. W. Emmons. The new Company has recently been incorporated with a capital stock of $100,000, and already the site formerly occupied by the American Steel and Wire Company, on the corner of Bay and Powell streets, has been leased for the manufacturing plant of the company.

It is significant of the importance of the dry battery industry to state that the predecessors of the Pacific Carbon and Battery Company were behind in their orders to the extent of above 60,000 cells, and that the demand for the Pacific Coast product of the Ecco Battery Company prior to its reorganization into the present corporation was so firmly established that the new concern is equipping its factory for the production of 150,000 dry batteries per month. In the manufacture of these Pacific Coast products are used to the fullest possible degree, even to the extent of manganese, an excellent quality of which is found in adundance in California.

That the Battery Company is maintaining a high standard of excellence in the manufacture of its dry batteries has long been recognized by all who have used them, whether in bill, momentary miniature lighting, telephone, automobile, mining or other open circuit service, and so meretorious are they that further improvement is impossible, if the products of Eastern dry battery manufacturers are taken as the criteria. And as to selling prices, any handicap that the San Francisco manufactures may labor under by reason of a lesser output and higher wages than prevail in the East, is at least offset by the difference in freight rates and the uniformly excellent quality of raw materials, both of which favor the local concern.

A CHANGE IN "STANDARD UNDERGROUND" OFFICES.

ANNOUNCEMENT is made that The Standard Underground Cable Company, on account of the general growth of its business on the Coast, has decided to discontinue all agency arrangements for the sale of its products, and on April 1st will open its new offices in the Rialto Building, San Francisco, with A. B. Saurman as manager for the Pacific Coast territory, which includes Washington, Oregon, Idaho, California, Nevada,

Arizona, British Columbia, Alaska and the Hawaiian Islands. Mr. Saurman has in turn been connected with the Standard Underground Cable Company in both construction and sales departments at Philadelphia and New York, and was later for several years manager of the Boston office, while for the past two years his position has been that of manager of the Pacific sales department.

The Standard Underground Cable Company expects to make early announcements of location and personnel of sub-sales offices at Los Angeles and Portland. It also reports that its factory at Oakland, Cal. (the only factory west of the Mississippi equipped with lead presses for cable work), has been unusually busy during the past six months, and that the future on the Coast points to its continued activity.

CHRISTENSEN AIR BRAKES FOR CLEVELAND.

FOR a number of years the steam railroads have used an air brake as their standard. The electric lines have experimented with various kinds of brakes to ascertain if they could not improve upon this type of brake for their work and the suburban electric roads have followed in the footsteps of the older organizations by adopting the air brake as their standard, the main difference being that the steam railroads use steam to compress the air for the brakes, while electric roads rely upon an electric motor.

When air brakes were originally tried by the electric roads, the manufacturer of these brakes relied upon a pump which was fastened to the axle of a car to compress the air. This type of brake was tried a number of years ago, but was not entirely satisfactory. The electric motor was then turned to in connection with a compressor to supply the air. The manufacturers have for a number of years been endeavoring to improve the motor and compressor, and have so far succeeded that if a road is willing to go to the expense of using this type of brake, very little risk is assumed.

A number of the larger cities, such as Philadelphia, Buffalo and Detroit have all their cars equipped with air brakes, same being installed as new and larger cars were purchased, but it remained for the Cleveland Electric Railway Company to place the largest contract for the individual air brake compressors that has ever been placed in this country. The decision was not arrived at until after two years' of experimenting with practically every known type of brake that is manufactured, and after an unparalleled test in the history of electric railroading. All the air brake manufacturers of this country were in competition for this order, as they fully realized the value of such a contract, both in regard to the money involved, and the effect it would have on other roads in this country.

The National Electric Company of Milwaukee, Wis., was awarded the contract last week, and is arranging to ship several car loads of air brakes which will be installed under the new convertible type of cars of the Cleveland electric railway immediately.

A NEW CONCERN IN THE WESTERN FIELD.

THE Benjamin Electric Manufacturing Company, of Chicago and New York, after studying the remarkable development of the Pacific Coast field, recently added San Francisco to its list of local headquarters by opening offices here in the Crossley Building with F. H. Ross, of St. Louis, in charge.

The company has enjoyed a wide reputation for its wireless clusters, consisting of a lamp socket arranged to receive a plurality of lamps. The popular form known as the Arc Burst is replacing arc lamps wherever a steady, soft and agreeable light is required. The Arc Burst is especially adopted to restaurants, stores, art galleries and large parlors, where a bright, evenly diffused light is desired.

The Benjamin Electric Company also make a specialty of sign sockets and twin sockets, the latter being especially adaptable to windows and show cases, as it enables the use of two lamps with one set of connections. The twin socket plug is arranged to receive two lamps end to end, with a plug on the side prepared to enter an ordinary lamp socket, thus changing the angle of the lamps by 90 degrees. All Benjamin sockets and clusters are adaptable to all sorts of weather conditions, for inside or outside use. All who are interested in these specialties may see them in operation at the local office in the Crossley Building.

A 16,000 HORSEPOWER MOTOR-GENERATOR SET.

ONE of the largest electric motors ever built is now being installed at the plant of the Shawinigan Water and Power Company, Shawinigan Falls, Quebec. This was recently constructed by Allis-Chalmers Company at its electrical works in Cincinnati, and embodies in its design the characteristics of the Bullock alternators, which have proven singularly successful in their application. It is a synchronous motor of 8000 horsepower. The rating of the generator operated by this motor, on standard specifications, is 5750 kilowatts at 300 revolutions per minute. The combined machines, in addition to their enormous capacity, are remarkable for concentrating in an exceedingly small floor space a volume of 12,000 kilowatts, or nominally 16,000 horsepower.

These machines were tested at the Bullock shops by the Behrend system under full load conditions, corresponding to 7200 kilowatts on the generator, with the expenditure of no more than 300 kilowatts in order to produce the same losses in the machine which exist under full load conditions.

The working of the generator and motor forming the frequency changer at Shawinigan Falls will be carefully noted by electrical engineers in all parts of the world, and if it is as successful as the builders confidently anticipate, the result will be a valuable addition to existing data on the subject of alternating current machinery.

MURALT POLYPHASE MACHINERY IN AMERICA.

ONE by one the European electrical manufacturers who are producing polyphase machinery are finding it advantageous to seek the American market, and the latest concern to take this important step is the firm of Muralt & Co., of Zurich, Switzerland, who have established American headquarters at 25 Pine Street, New York City, together with sales offices in practically all the larger cities of the country.

Messrs. Muralt & Co., are specialists in alternating current work, and they produce a complete line of single-phase and polyphase alternating current generators, transformers and motors, all designed not only to a view of achieving the greatest possible measure of efficiency but also with a view to rendering them wholly reliable and safe even in the hands, they claim, of unskilled attendants. Their machinery is operated in some of the largest stations of Europe, notably at Lyons, France, where 26,000 horsepower is installed; its induction motors are of both the single-phase and polyphase type, as are also its transformers, and its switches are of every type, including oil switches for tensions up to 40,000 volts.

Messrs. Muralt & Co., will be glad to furnish literature descriptive of their apparatus on application to their New York office at the address stated.

THE ANNUAL CROCKER-WHEELER CONVENTION.

The annual convention of officers and branch managers of the Crocker-Wheeler Company took place at the main office and works, Ampere, N. J., on January, 26th, 27th and 28th. Managers and representatives were in attendance from all parts of the country, and were unanimous in predicting a prosperous season during the coming year in the field of alternating current generators and direct current generators and motors. On the evening of the 27th a banquet was held at the Cafe Martin, in New York, at which the president of the company, Dr. Schuyler Skaats Wheeler, presided.

MORRIS TURBINES AND PUMPS.

BULLETIN No. 1, issued by the I. P. Morris Company, and which relates to turbines and centrifugal pumps, is a very interesting presentation of the hydraulic features of some of the most notable installations of America. This concern, which is widely known as the Point Richmond Iron Works, dates its origin to 1828, and during the Civil War it achieved prominence by designing and building the engines for the double turrited monitors Monadnock and Agamenticus. The list of notable engine installations which it has built is a very long and most creditable one, but most prominent among them are the Louisville pumping engine which has, in establishing a record of 1205 pounds of steam per indicated horsepower per hour and a duty of 151,672,000 foot-pounds per 1000 pounds of steam, proved itself to be the most economical pumping engine in the world, and the Boston sewage pumping engine which, with a daily capacity of 72,000,000 gallons and a weight of 1,500,000 pounds, is the largest in the world. As for steam engines, the 15,000 horsepower engine serving the 14,000-ton hydraulic press at the Bethlehem Steel Works is the most powerful in existance.

When the Niagara Falls Power Company's plant was first projected, the I. P. Morris Company was the one selected to undertake the building of the turbines—the largest up to that time. These involved castings of such great size and difficult mechanical features that the Morris Company was found to be the only concern then equipped to undertake this class of work. The first installation consisted of ten units of 5000 horsepower each.

Since then the same concern has also built the eleven larger turbines of 5500 horsepower each for the second power plant. This company has recently completed and is now installing two turbine units of 10,000 horsepower for the Canadian Niagara Power Company and one of 10,500 horsepower for the Shawinigan Water and Power Company. The latter are said to be the largest water power units in the world. In the building of heavy centrifugal pumping machinery the I. P. Morris Company also takes a high stand. Reference may be made to the pumps installed in the stations of the New Orleans Drainage Commission, which are not only the largest centrifugal pumps ever built, but show an efficiency never before obtained under similar conditions of service. The equipment of these and many other interesting installations are beautifully illustrated and described in the catalogue referred to.

THE RECORD RUN OF THE WORLD'S FAIR TURBINE.

A MEMORABLE incident of the morning following the close of the St. Louis Exposition was the formal shutdown and inspection of the 600 horsepower Westinghouse steam turbine generating unit in the Palace of Machinery after a continuous run of over 3962 hours—a performance which has had no parallel in steam turbine history. This machine was started on its long run at 9:20 o'clock on the morning of Monday, June 20th, shortly after its installation at the Fair, and was stopped at 11:32 o'clock on the morning of Friday, December 2d. During the five and a half months that the unit was in operation it supplied current for light and power throughout the Westinghouse exhibits in the Palaces of Machinery, Electricity and Transportation. Charles F. Foster, chief operating engineer of the Exposition, H. M. Holman, supervising engineer at the Government Exposition gas engines tests, formerly president of the St. Louis Board of Public Works, and a number of Westinghouse representatives, including Wallace Franklin, of Detroit, C. C. Chappelle, of Chicago and W. K. Dunlap, managing director of the Westinghouse exhibits, were present when the engine was stopped. It was found to be in perfect condition, and there were no signs of wear, the bearings still retaining the tool marks as they had come from the shops.

There have been at least two instances on record in America in which piston engines have been run continuously for about the same length of time as that of the record run of the Westinghouse turbine. The remarkable feature of the turbine run, of course, was the maintenance under load of a speed of 3600 revolutions a minute for such a long period. From 8:30 o'clock in the morning to 10:30 o'clock in the evening, the load carried throughout the Exposition varied from 25 per cent. underload to 25 per cent. overload. The total number of revolutions almost touched the billion mark—855,792,000.

"THE INSULATOR BOOK."

A TRADE publication of late date and which is consequently of great interest to transmission engineers because it displays the most recent advances in the art of making high tension insulators, is found in "The Insulator Book" issued as Catalogue No. 8, of The Locke Insulator Manufacturing Company, of Victor, N. Y. This catalogue is issued with the idea of bringing before the engineering world the types of insulators which are recognized as being the best adapted to service under various climatic conditions. In the designs there listed it has been the endeavor of the manufacturers to eliminate all those of various types which have proven to be defective, as well as to simplify and to bring to standard forms all varieties of insulators used under ordinary transmission potentials. The catalogue expresses appreciation of the fact that the art of insulator making itself must necessarily be in advance of any specific date that may be published, nevertheless the hope is held that the present brochure will, in a general way, present latest developments and indicate to practicing engineers the lines along which progress is desired.

Some valuable information concerning the testing of insulators appears in the book in an introductory way. Then follow descriptions of all of the many varities of insulators produced by the concern named, together with dimensional data of each. Both glass and porcelain goods are described as are also practically every conceivable variety of insulator pins and brackets. The catalogue contains fifty-six pages, is of much typographical merit and may be obtained on application to either the company named at Victor, N. Y., or Jno. Martin & Co. San Francisco, its Pacific Coast agents.

LUNDELL MOTORS BY THE NATIONAL COMPANY.

ANNOUNCEMENT is made that Robert Lundell, under whose original patents the line of direct current motors now produced by the Sprague Electric Company is being manufactured, has entered the service of the National Electric Company, of Milwaukee, Wis., and that by the consummation of this arrangement the company named will manufacture and market the electric motors and generators and systems of control covered by the latest of Mr. Lundell's patents. It is perhaps needless to say that the National Electric Company regards Mr. Lundell's new invention to embody a marked development over his former work, the origin of which dates back some eight or ten years.

The main features of this apparatus consist of a motor in which the yoke is of laminated steel, having about the same thickness as the pole piece laminations, and a new type of brush holder, and important patents covering methods of control particularly applicable to electric elevators and automobiles.

The laminated yoke construction is a most important development in the art, and in conjunction with the new commutation methods involved in the new brush holder, both combined with important elements of design, results in a motor much more compact and efficient and a commutator that will be cooler than the armature, flexible field control, all of which can be marketed at the prevailing rates now being paid for apparatus of inferior characteristics. These motors will be built up from standard dies and jigs, a full line of which is now being pushed forward to an early completion.

It is felt that these Lundell machines will be a valuable acquisition to the already well established line of electrical apparatus of the National Electric Company.

NEW INCORPORATIONS.

TOLUCA, CAL.—The Lankershim Water Protective Association has been incorporated, with a capital stock of $125,000, by A. J. Gwynn, L. W. Gregg, A. M. Cormick, W. C. Waddington and J. W. Deupree.

PARRAL, MEX.—The Conchos River Power Company has been incorporated by Lafe Pence, Joseph Lyons, C. E. Idleman and others, with a capital stock of $100,000, for the purpose of building an irrigation system.

LOS ANGELES, CAL.—The Osage Fifty-Eight Oil Company has been incorporated with a capital stock of $500,000, its directors being E. K. Potter, of Santa Ana, and A. R. Field, E. S. Lovett and others of Los Angeles.

RIVERSIDE, CAL.—The Rivino Water Company has been incorporated, with a capital stock of $75,000, its directors being Chas. C. Hall, Frederick F. Hall, of Berkeley, and A. H. Halsted, L. V. W. Brown and W. W. Wilson, of Riverside,

SPARKS, NEV.—The Washoe Deep Well Association has been incorporated, with a capital stock of $125,000, by G. E. Clough, J. E. Humphrey, G. W. Robinson and others for the purpose of building a water works system for this town.

SEBASTOPOL, CAL.—The Sebastopol Light, Power and Water Company has been incorporated by W. F. Inglish, W. Y. McBride, T. L. Gates, of Vacaville, G. W. Kingsbury and A. B. Swain, of Sebastopol, with a capital stock of $25,000.

LOS ANGELES, CAL.—The Coachella Artesian Water Company has been formed with a capital stock of $30,000, its directors for the first year being Warren Gillelan, R. W. Kenney, L. B. Rector and others of Coachella, where its principal place of business will be located.

RIVERSIDE, CAL.—The Auburndale Water Company has been incorporated, with a capital stock of $25,000, for the purpose of developing water for the Auburndale tract near Corona. Its incorporators and directors are Priestly Hall, Agnes O. Hall, Geo. Frost and others.

SPOKANE, WASH.—The Electric Water Company has been incorporated, with a capital stock of $50,000, by R. A. Hutchinson, A. C. Jameson, J. E. Hoppe, D. K. McDonald and C. F. G. Patullo, for the purpose of irrigating about 1000 acres of land located six miles east of Spokane.

SAN FRANCISCO, CAL.—The Battle Creek Power Company has been incorporated with a capital stock of $1,000,000, of which $100 each has been subscribed by Henry Ward Brown and Walter E. Carre, of Colma and Harold L. Wright, Dudley C. Bates and Joseph E. Barry, of San Francisco.

SAN FRANCISCO, CAL.—The Oregon Water, Light and Power Company, with a capital stock of $3,500,000, of which $1000 each has been subscribed by the following directors: J. A. Kretchmar, J. Alexander and A. Harvey, of San Francisco, and R. C. Medcraft and L. A. Redman, of Alameda.

PRESCOT, ARIZ.—The Morse Light and Power Company has been incorporated under the laws of Arizona, with a capital stock $1,000,000, by Henry D. Stanley, Samuel B. F. Morse and Brayton P. Stanley, for the purpose of engaging in the building and operation of electric light and power plants.

SAN FRANCISCO, CAL.—The National Electric Contracting Company has been incorporated, with a capital stock of $50,000, of which $700 has been subscribed, the incorporators being D. L. Randolph, J. G. Whitney, C. C. Pomeroy, Jos. Knowland, Henry Kregs, B. R. Hecht and Ferdinand Riese, Jr.

OREGON CITY, OR.—The Estacada Telephone and Telegraph Company has been incorporated for the purpose of building an independent telephone system in Clackamas County. Its capital stock is $10,000, and its incorporators are M. C. Adkins, B. O. Boswell, J. B. Haviland, R. W. Reed and R. A. Stratton.

REDDING, CAL.—The Mount Burney Rural Telephone Company, of Burney Valley, has been incorporated by forty residents of Burney Valley and Fall River Valley, its purpose being to build and operate a telephone line from Montgomery Creek to Pittville, with branches through Goose Valley and Hat Creek.

HONOLULU, T. H.—The Kauai Electric Company (Ltd.) has been incorporated by D. P. R. Isenberg, H. W. M. Mist, Geo. M. Davies and others with a capital stock of $300,000 for the purpose of furnishing electric power to the plantation in Garden City, to own land and to operate electric car lines, telephone and telegraph systems.

LEWISTOWN, MONT.—The Lewistown and Billings Mutual Telephone Company has been incorporated; capital stock $20,000; principal place of business, Lewiston, and incorporators, P. B. Moss, of Billings, Thos. Cruse, of Helena, F. W. Handle, of Musselshell, and G. M. Stone, G. J. Bach, David Gilger and E. Q. Busenburg, of Lewiston.

The Standard Electrical Construction Company has incorporated the Standard Electrical Works, which corporation has taken over the machinery and supply business, retaining the engineering and construction business, as in the past. The offices and place of business of the new company are the same as the Construction Company, 120-130 New Montgomery Street, Rialto Building, San Francisco, Cal.

SANTA MONICA, CAL.—The Citizens Gas and Electric Company has been incorporated, with a capital stock of $60,000, of which $7500 has been subscribed. The directors are: F. E. Bundy, Santa Monica; C. C. Rathbone, A. C. Barke, A. E. Robinson, Ocean Park; F. C. Lamb, N. K. Potter and S. F. Wiles, Los Angeles. This company proposes to build its plant on the corner of Ninth Street and Colorado Avenue, and expects to be in operation by July 1st.

FINANCIAL.

EUREKA, CAL.—Messrs. Green and O'Brien have purchased of J. C. Bull, Jr., two-thirds of the stock of the Humboldt Transit Company.

BALLARD, WASH.—The Ballard Electric Company is applying for a new franchise as the present one contains restricting clauses which make it difficult to secure further capital.

OCEAN PARK, CAL.—Abbott Kinney has sold one-half interest in the Park Water Company to Messrs. Jones, Gage and Fraser for $65,000. At least $20,000 is to be spent in betterments.

ORANGE, CAL.—The Adams-Phillips Company, of Los Angeles, have purchased a $50,000 issue of municipal water bonds of Orange for par and accrude interest. The bonds bear 4½ per cent. and run for forty years.

VISALIA, CAL.—The Consolidated Heat, Light and Power Company has filed a certificate for the creation of a bonded indebtedness of $60,000 to be issued in $500 twenty year gold bonds. No other indebtedness exists.

AMERICAN FORK, UTAH—New officers of the Utah County Light and Power Company have been elected as follows: Abel John Evans, president; C. B. Harper, secretary; James H. Clarke, treasurer; John H. Wooton, manager.

ARCATA, CAL.—The Arcata Light and Power Company has elected officers to serve from one year from February 20th, as follows: President, Brousse Brizard; vice-president, E. E. Skinner; secretary, L. J. Archer; treasurer, Bank of Arcata.

ANAHEIM, CAL.—A meeting of the stockholders of the Anaheim Union Water Company will be held on April 22d, to vote on increasing the bonded indebtedness of the company from $114,500 to $300,000 to bear interest not exceeding 6 per cent.

SAN JOSE, CAL.—At the annual stockholders meetings of the Saratoga Mutual Telephone Company the retiring officers were re-elected as follows: Ralph A. Husted, president; James T. Richards, secretary; Dr. R. L. Hogg, treasurer; J. M. Lipscomb, W. G. Tomilson.

VENTURA, CAL.—The Ventura Water, Light and Power Company has filed with the Town Board its annual report, which shows the following figures: Receipts, water rates inside city

limits, $13,528.25; water rates outside, $1592.12; irrigation outside, $1403.52; service connections, $128.50; total, $16,652.39. Expenditures, taxes and insurance, $1469; interest on bonds, $10,440; office expense, $2574.50; general expense, $2148,79; construction $1756,36; total, $18,388.65. Total capital invested, $182,793.22; deterioration, $5000.

SAN FRANCISCO, CAL.—The stockholders of the Truckee River General Electric Company, on March 11th, voted to increase the capital stock from $2,500,000 to $3,000,000, divided into 60,000 shares of a par value of $50 each. The company is now paying dividends monthly at the rate of $1.20 per year per share. Secretary Herbert Fleishhacker says that the increase was advisable on account of the construction of a second generating plant on the Truckee River, which is to be in operation next October, when a new ten year contract for supplying electric power to the mines in the Comstock Pumping Association at Virginia City will go into effect. The earning capacity of the company will be increased by the new installation, which will have a capacity of 1500 kilowatts to start with, and is capable of extension.

SAN FRANCISCO, CAL.—In discussing the cost of a municipal gas plant before the Board of Supervisors, S. L. Naphtaly, general superintendant of the San Francisco Gas and Electric Company, stated that the gas works of his company could be reproduced for $14,980,190.54; that they cost $17,439,770 and that they had a capacity of 14,000,000 cubic feet a day. He estimated that the maximum daily consumption for 1905 would reach 13,000,000 feet. In his opinion a depreciation of 5 per cent. should be allowed for the plant and 2½ per cent. for the distributing system. The value of gas plants not in use except as auxiliaries was placed at $600,000; and the value of real estate was given as $800,000. W. B. Bourn, president of the company, assured the Supervisors that there was no "water" in the "amalgamation" of the companies last year, the property of each being taken at the cost shown by its books, the total being $10,136,274.85, plus $802,494.49, which was paid out of the surplus fund of the San Francisco Gas and Electric Company, reducing that fund to $45,910. The "amalgamated" companies were then capitalized at cost. All the inventories were checked up and the books were experted before the amalgamation was ratified. No examination was made, however, to demonstrate the value of the plants, the books and the statements of the officers of the companies being accepted as correct.

SAN FRANCISCO, CAL.—On March 11th regular monthly dividend No. 11 of 25 cents a share was paid by the California Gas and Electric Corporation. The comparative statement of the operations of this company for the month of January show the following increases: Gross earnings, $155,513.72; expenses, $122,656.65; profit, $32,857.07; corporation bond interest, $3,388.90, and net surplus, $29,468.17. The official statement for January, 1904 and 1905, is:

	1904.	1905.
Gross earnings	$ 276,513.05	$ 432,026.77
Operation, taxes, insurance, interest, etc.	183,529.62	306,186.27
Profit	92,983.43	125,840.50
Corporation bond interest	33,333.33	36,722.23
Balance	59,650.10	89,118.27
Sinking fund	12,500.00	12,500.00
Net surplus	47,150.10	76,618,27

The comparative statement of earnings and expenses for the eleven months to Jan. 31, 1905, is as follows:

	1903-4	1904-5
Gross earnings	$2,615,443.38	$3,965.599.81
Operation, taxes, interest, insurance, etc	1,858,532.46	2,912,703.98
Profit	756,910.92	1,052,895.83
Corporation bond interest	360,952.44	401,305.56
Balance	395,958.48	651,590.27
Sinking fund	137,500.00	137,500.00
Net surplus	158,458.48	514,090.27

STOCKTON, CAL.—On March 1st there was due $300,000 worth of 6 per cent. bonds of the Stockton Gas and Electric Company. Through efforts which have been making for some time the greater part of these bonds were extended to January 1, 1909, interest payable semi-annually at the rate of 6 per cent. The few which were not extended were taken up by the company.

SALT LAKE, UTAH—An ordinance is under consideration by the Counsel confirming the transfer of all franchises of former corporations to the Utah Light and Power Company. It ratifies the transfer of franchise from one corporation to the other and grants an extension of fifty years. The proposed franchise includes the franchise for the electric and gas departments of the company upon the same lines as contained in existing franchise.

LOS ANGELES, CAL.—The Home Telephone and Telegraph Company, of Los Angeles, Cal., in its annual stockholders' report for 1904, covers in detail the quarterly earnings for its entire first year's business. After enumerating its extensions the report says that because of the increased number of telephones installed the earnings should be even greater than shown in the statement submitted:

Earnings for first quarter, ending December 31, 1903	$67,633.71
Operating expenses, taxes, insurance, maintenance and interest on bonds	45,274.10
Available for dividends, improvements or surplus	$22,359.61
Dividends paid Jaunary 10, 1904	17,330.00
Surplus	$ 5,029.61
Earnings for second quarter, ending April 1, 1904	79,698.59
Operating expenses, taxes, insurance, maintenance and interest on bonds	47,881.08
Net earnings for quarter	$31,817.51
Surplus from last quarter	5,029.61
Available for dividends, improvements or surplus	$36,847.12
Dividends paid April 10, 1904	18,980.00
Surplus	$17,867.12
Earnings for third quarter, ending July 1, 1904	86,944.39
Operating expenses, taxes, insurance maintenance and interest on bonds	50,469.46
Net earnings for quarter	$36,474.93
Surplus from last quarter	17,867.12
Available for dividends, improvements or surplus	$54,342.05
Dividends paid July 10, 1904	20,080.00
Surplus	$34,262.05
Earnings for fourth quarter, ending October 1, 1904	89,867.22
Operating expenses, taxes, insurance, maintenance and interest on bonds	51,946.00
Net earnings for quarter	$37,921.22
Surplus from last quarter	34,262.05
Available for dividends, improvements or surplus	$72,183.27
Dividends payable November 10, 1904	21,580.00
To surplus	$50,603.27

The reader will not fail to note that the dividends paid by this company are stated quarterly, thus: January 10, 1904, $17,330; April 10, 1904, $18,980; July 10, 1904, $20,080; November 10, 1904, $21,580—a total annual dividend of $77,970. Also that the net dividend by quarters was a steady proportionate increase in each quarter, from $17,330 in the first quarter to $21,580 in the concluding quarter of the year, with a grand disbursement total of $77,970 for the first and most expensive year of the company's life.

SAN FRANCISCO, CAL.—The San Francisco Gas and Coke Company has arranged for an issue of $2,500,000 in 5 per cent. forty-four year gold bonds to be underwritten by the Knickerbocker Trust Company, of New York. Leopold Wallach, its attorney states that the company will be in operation during the first week in April and that it will sell gas at the rate of 75 cents per thousand.

SAN FRANCISCO, CAL.—In the annual report of W. B. Bourn, president, to the shareholders of the San Francisco Gas and Electric Company, it is stated that the operations of the company during the past year brought to a realization the estimated benefits and results that were expected to accrue from the purchase of the interests that were acquired last year. The revenue of the company for the fiscal year amounted to $4,393,277.68, against an operating and maintenance expenditure of $2,064,926.35. Fixed charges for taxes ($118,065.08) and bond interest ($444,852.50) amounted to $506,917.58. Depreciation, replacement, contingent and other necessary funds were credited the sum of $700,000, leaving $1,065,433.75 available profit for the year. The accompanying financial statements bring clearly to point the summary of the year's business. ..... Great progress has been made in betterments, extension and replacements, as laid down in the general plan outlined in former reports. Following these installations are the attendant results, improved service and greater economy in manufacture and distribution. The report then states: "We regret that the company is not in a position to distribute to its shareholders dividends more commensurate with the nature of their investment, and no increase in the dividend rate may be expected until the future is protected with a proper surplus fund. We know, however, of no condition likely to arise that will affect the return now made to shareholders."

Appended thereto is the following profit and loss account January 1, 1904, to December 31, 1904.

CHARGES.

GAS.

Generator fuel	$ 303,508.70	
Boiler fuel	12,288.79	
Gas oil used	249,850.61	
*Wages and salaries	204,896.23	
Legal expenses	3,377.54	
Taxes	76,789.14	
Gas stoves	23,096.12	
Repairs, maintenance and general expenses	448,400.99	
Amount written off to replacement, depreciation and contingent fund	375,000.00	
Amount written off to insurance, fire and accident fund	25,000.00	
Bond interest	227,398.76	
		$1,949,606.88

ELECTRIC.

Fuel oil used	$ 270,395.63	
*Wages and salaries	228,844.39	
Carbons	16,311.68	
Legal expenses	3,953.28	
Taxes	41,275.94	
Current purchased	8,101.94	
Repairs, maintenance and general expenses	291,895.46	
Amount written off for replacement, depreciation and contingent fund	275,000.00	
Amount written off to insurance, fire and accident fund	25,000.00	
Bond interest	217,453.74	
		1,378,237.06
		$3,327,843.94

*Wages on repairs and maintenance not included.

REVENUE.

GAS.

Sales of gas	$2,469,356.38	
Tar residuals	17,269.39	
Wharfage, discharging vessels and rents receivable	13,769.70	
Sundries	50,457.04	
		$2,550,852.51

ELECTRIC.

Sales of current	$1,791,362.69	
Sales of steam	6,751.89	
Rent receivable	1,830.00	
Sundries	42,480.60	
		1,842,425.18
		$4,393,277.69
Revenue		$4,393,277.69
Charges		3,327,843.94
Net available profit for year		$1,065,433.75
Dividends paid during year		792,421.68
Surplus for year 1904		273,012.07

The balance sheet on December 31, 1904, is given as follows:

ASSETS.

Real estate, construction and plant	$15,190,623.45	
Pipes, street lamps (gas), conduits arc lamps and pole lines	10,863,133.17	
Patents and licenses	150,000.00	
Oil, coal and purifying materials	263,570.28	
Cash on hand	19,276.48	
Sundry assets	108,614.57	
Supplies and tools on hand	240,016.78	
Amount due from consumers (gas and electric)	303,444.89	
Investments (bonds)	980,000.00	
		$28,118,679.62

LIABILITIES.

Capital stock, of 200,000 shares of $100 each	$20,000,000.00	
Of which have been issued 158,484⅓ fully paid shares at $100	15,848,433.33	
Less stock discount on 2973⅓ shares	54,148.97	
		$15,794,284.36
Bonds issued by S. F. G. & E. Co., (thirty years, 4½ per cent)	8,021,000.00	
Bonds issued by P. G. I. Co., (thirty years, 4 per cent)	1,169,000.00	
Bonds issued by Edison L. & P. Co., (6 per cent)	623,000.00	
Bond interest	64,201.66	
Uncollected dividends	14,902.35	
Unpaid pay-rolls	67,707.33	
Notes payable	830,000.00	
Outstanding and suspending accounts	317,838.06	
Replacement, depreciation, contingent and insurance funds	997,910.45	
Surplus December 31st	218,835.41	
		$28,118,679.62
Surplus December 31, 1903		$ 45,910.84
Surplus profits, 1904		273,012.07
		$ 318,922.91
Equitable stock charged off		100,087.50
Net surplus		$ 218,835.41

OAKLAND, CAL.—The comparative statement of the earnings of the Oakland Traction Consolidated for January, 1904 and 1905, is as follows:

	Gross earnings	Expenses.	Net earnings
1905	$104,673.00	$61,520.69	$43,152.31
1904	94,510.89	52,309.10	42,201.70
Increase	10,162.11	9,211.59	950.52

The fixed charges were $30,484.70.

The heavy increase in expenses is due to the additional car service given on many of the lines. During the last year the most notable increases in service occurred on the Oakland Avenue line changed from fifteen-minute to seven and one-half-minute headway, and East Eight Street, fifteen-minute to ten-minute. In addition to these, several other lines have had extras put on daily during the busy hours and on Sunday, notably on the Haywards line. Altogether, the service has improved 25 per cent. in the last year.

GAS.

SANTA MONICA, CAL.—A. C. Barke has applied for a gas franchise.

FULLERTON, CAL.—F. W. Butler has been awarded a fifty-year franchise for a gas plant.

SAN BERNARDINO, CAL.—The Home Gas and Lighting Company began laying its gas mains in San Bernardino on March 6th.

SAN FRANCISCO, CAL.—The Board of Supervisors has fixed the legal rate for gas for the year beginning July 1, 1905, at $1.00 per thousand.

TUSCON, ARIZ.—The Tuscon Electric Light and Gas Company will lay between five and ten miles of new gas mains by the middle of next summer.

LODI, CAL.—H. C. Keyes, of the Sacramento Natural Gas Company proposes to sink a natural gas well here, gas to be sold at $1.25 per thousand.

HONOLULU, T. H.—The Honolulu Gas Company is erecting its new gas works in the Iwilei district, and expects to be in operation in part by June 1st.

RENO, NEV.—The Reno Power, Light and Water Company (Ltd.) is building a new gas plant from which gas will be supplied throughout Reno and Sparks.

BAKER CITY, OR.—I. W. Anderson, president of the Spokane Falls Gas Light Company, has purchased the gas and electric light and power plant of this city for $400,000.

PENDLETON, OR.—I. W. Anderson, president of the Spokane Gas Light Falls Company, and who represents Eastern interests, will install a 50,000 cubic feet gas works in this city this summer.

PORTLAND, OR.—The Portland Gas Company is to erect a new holder that will have a capacity of 1,500,000 cubic feet. It will cost about $200,000 and if possible will be ready for use by October 1st.

COVINA, CAL.—The new works of the Covina Valley Gas Company, were placed in operation on February 21st. The plant cost $30,000, it starts with 100 consumers and sells gas at the rate of $1.75 per thousand.

PALO ALTO, CAL.—Two carloads of three-inch gas pipe are being laid by the Palto Alto Gas Company for the high pressure supply main between College City and Redwood and between Palo Alto and Redwood.

HOLLYWOOD, CAL.—Citizens are discussing the advisability of installing a municipal gas plant with the alternative of inducing the Los Angeles Gas and Electric Company to extend its high pressure mains to Hollywood.

ABERDEEN, WASH.—C. E. Burrows, of Walla Walla, has secured franchises for the installation of a gas plant in the cities of Aberdeen and Hoaquin. The equipment has been ordered and construction is well underway.

MARYSVILLE, CAL.—A flow of natural gas has been found on the Norton Ranch owned by Jno. Reynolds and which is situated four miles east from here. The supply seems to be permanent and the gas burns freely with a clear white light.

CITY OF MEXICO, MEX.—The Avino Mine, of Avino, in the State of Durango, is installing a gas producer plant for the operation of a gas engine that is to drive a 300 horsepower electric generator whence will be operated motors used by the hoists and air compressors about the mine.

SANTA MONICA, CAL.—As soon as the City Trustees give consent the recently incorporated Citizens Gas and Electric Company will begin the erection of its gas works. About 800 consumers' contracts have been signed and it is stipulated in these that the plant will be in operation by July 1st.

SANTA ROSA, CAL.—The Santa Rosa Lighting Company is soon to lay a two-inch steel tube from this city to Petaluma, a distance of sixteen miles. This tube will supplement the two inch pipe already laid and which has been in operation for the high pressure transmission of gas to Petaluma for three years.

VISALIA, CAL.—Work has been begun on the new gas plant of the Consolidated Heat, Light and Power Company. About 60,000 feet of gas main has already arrived and is being laid and the compressor has been installed. A 500 barrel oil tank is being erected and it is believed that the system will be in operation within sixty days.

SEATTLE, WASH.—The American Improvement Company has applied for a gas franchise for this city, agreeing to deposit $25,000 with the city treasury as a guarantee that it will faithfully carry out the provisions of the franchise, which states that it must be selling gas in Seattle at the rate of eighty-five cents per thousand within two years.

SACRAMENTO, CAL.—Julius Simonson, Bert Steinhorff and Fremont McCauley employees of the Sacramento Electric Gas and Railway Company, at the Gas Works on Front and T streets were seriously burned on February 26th by an explosion of gas in one of the scrubbers at the works. The three men were engaged in cleaning out the scrubber when Simonson, who was in charge, lighted a match to see if its floor was well cleaned. Instantly there was a terrific explosion from the effects of which Steinhorff and McCauley may recover but it is believed that Simonson will not survive.

TRANSPORTATION.

ARCATA, CAL.—J. E. Green and J. M. O'Brien have been granted a railway franchise in Arcata.

BENICIA, CAL.—The Board of Trustees has invited the proposals for an electric railway franchise.

VISALIA, CAL.—Grading is progressing rapidly on the Visalia Electric Railway line between Exeter and Lemon Cove.

ALBUQUERQUE, N. M.—The Albuquerque Traction Company is adding several miles of track to the local street car system.

MODESTO, CAL.—H. B. Kinney has applied for an electric railway franchise to cover certain highways of Stanislaus County.

ANAHEIM, CAL.—Efforts are being made to induce the Pacific Electric Railway Company to extend a branch line into Anaheim.

OGDEN, UTAH—The Amalgamated Sugar Company has applied for a franchise for an electric road to be built in Cache Valley.

SAN LOUIS OBISPO, CAL.—The Board of Trade is giving consideration to the construction of an electric railway line to the beach.

HOLLISTER, CAL.—The building of the standard gauge electric road between Hollister and Watsonville is believed to be assured.

SONOMA, CAL.—S. Schoken and Oscar T. Weber have been granted an electric railway franchise covering certain streets of this city.

SANTA ROSA, CAL.—O. D. Baldwin has been awarded a county franchise for an electric railroad to be built from Sonoma to Embarcadero.

OROVILLE, CAL.—The Northern California Electric Railway Transportation Company has applied for a local electric street railway franchise.

SAN BERNARDINO, CAL.—As soon as rights of way matters are settled the San Bernardino Valley Traction Company will extend its lines to Arrowhead.

BURBANK, CAL.—The Los Angeles California Glendale Electric Railway will be extended to Burbank provided a bonus of $25,000 and a right of way be given.

SACRAMENTO, CAL.—Arthur Filmer, of Sacramento, is endeavoring to organize a company for building an electric railway line from this city to Walnut Grove.

STOCKTON, CAL.—The Stockton Electric Railway Company is changing its roadbed, and by July 1st will have added twenty new thirty-foot cars to its system.

REDDING, CAL.—It is stated that the Northern California Power Company will build an air line electric road from Redding to Kennett, with a branch running west to Keswick.

BOISE, IDAHO—W. E. Pierce has applied for a street railway franchise agreeing to begin construction within one year, and to complete one mile of track within two years.

EL PASO, TEX.—F. W. Potter and Alfred A. Rasmus have secured a franchise for the proposed McKinley and Bonham Electric Railway, work on which is already under way.

PASADENA, CAL.—In all probability the Pacific Electric Railway Company will extend their line through La Canada shortly, as the bonus of $10,000 asked for by the company has been subscribed.

SANTA BARBARA, CAL.—E. W. Clark and assigns has been granted a franchise for an electric railway to run through certain streets in the town of Santa Maria, thence along country roads of Santa Barbara County from Santa Maria to Guadaloupe and in the town of Guadaloupe.

MERCED, CAL.—N. S. Ray is authority for the statement that work will begin at once on the construction of an electric railway line that will be built from Merced up to Merced River Canyon to within six miles of Yosemite Valley. Mr. Ray is chief engineer for the enterprise.

SANTA ROSA, CAL.—The Petaluma and Santa Rosa Electric Railway Company has begun the extension of its lines from Green Valley to Forrestville, and it is stated that in all probability the next important extension on which work will be begun will be that of building a line from Santa Rosa to Healdsburg, a distance of twelve miles.

SPOKANE, WASH.—Jno. R. Price has purchased over 20,000 acres of land at Box Canyon, including valuable water rights, which will be developed by the Northwestern Mammoth Granite and Electric Power Company, which will begin work thereon by May 1st. This company also proposes to build an electric railroad from Box Canyon to Spokane.

SAN FRANCISCO, CAL.—The Examiner reports that E. H. Harriman has purchased a half interest in the H. E. Huntington Electric Company which was recently formed with an authorized capital of $5,000,000 for the purpose of building some 200 miles of electric road out from Fresno, including the Yosemite lines of about ninety miles, that will run between Fresno and Wawona.

STOCKTON, CAL.—A. C. James, representing Eastern capitalists, is endeavoring to enlist the support of the Stockton Chamber of Commerce in securing franchises and rights of way for an electric road to run from Stockton to Tonopah, with a branch to Yosemite Valley, covering a total length of 125 miles. Power for the operation of the system will be developed by water, of which an ample amount is available, so that 60 per cent. of its output can be sold commercially.

OXNARD, CAL.—It is reported that work is soon to be begun at Oxnard on the electric road that is to be built to Bakersfield. This is on the authority of Jno. Burson, the head of the Oxnard-Bakersfield road enterprise, who states that the company's bonds to the amount of $200,000 have been sold and the money is ready for immediate use. He further states that tide water will probably be reached somewhere north of Hueneme instead of at Hueneme as first proposed.

CHEHILIS, WASH.—The Chehilis Eastern Railway Company recently incorporated with a capital stock of $2,000,000 by Francis Donohue, T. C. Rush, C. N. Guirgrich, W. E. Harmon, Dr. J. T. Boleman, J. L. Sticklin, Daniel W. Bush, all of Chehilis, and Chas. W. Taylor, of Everett, proposes to build an electric railway seventy miles in length to run from Chehalis to Sulphur Springs. The company will build a power plant and will carry passengers, coal, lumber, garden produce and general freight.

TACOMA, WASH.—This city has 140 miles of electric street railway track, includes in its rolling stock 245 freight and passenger cars, owns its power plant, carries 559 men upon its payroll, and pays more taxes than any corporation or individual in Pierce County excepting the Northern Pacific Railway. It has fine terminal car barns, offices and car building and repairing shops in Tacoma. During 1904 the company finished standardizing all of its lines with seventy-two-pound steel rails, and double tracked a greater part of the system.

SALINAS, CAL.—The Monterey County Gas and Electric Company proposes to construct an eighteen mile electric railroad to carry passengers and freight between Monterey and Salinas provided a bonus of 50,000 and a fifty-foot right of way are given. It is stated that the road will cost $300,000 of which $54,000 will be paid for rails. Construction will commence within four months after the bonus and rignt of way are furnished and the system will be completed within fifteen months thereafter. It is intended to ultimately extend the road to Hollister and later into the San Joaquin Valley and Fresno along the survey of the old Monterey and Fresno road.

SPOKANE, WASH.—Certain capatilists are investigating the advisability of installiug an electric railway line to connect the big mines of Shoshone County, Idaho, with Coeur d'Alene City. The route proposed will run from Coeur d'Alene through Fourth of July Canyon, thence by the Old Mission to Wallace, this being the route selected by the Northern Pacific Railway in 1887. The distance from Coeur d'Alene to Mission, thirty-one miles, and from Mission to Wallace, twenty-eight miles. The cost of the road is estimated at $600,000. The projected road will make it possible to make the trip between Spokane and Wallace via the Coeur-d'Alene Electric line in about three hours. It is expected that the new line will carry from 400 to 500 passengers per day from the outset.

SEATTLE, WASH.—The Spokane-Inland Railway Company recently organized to build an electric railway through the Palouse Valley to Moscow and Pullman, Idaho, has five crews of surveyors in the field and is preparing to build an electric power plant on the Spokane River, nine miles below Spokane, where the company claims it can develop 15,000 horsepower. Preliminary to the building of the water power plant, a steam plant of about 3000 horsepower will be built to supply power as the road is built. Freight will be handled through the valley. Jay P. Graves, president of the new company, is also heavily interested in the Spokane Traction Company and Coeur d'Alene and Spokane Railway Company. A large building will be erected in Spokane, to be used as offices and a terminal for the three companies.

TRANSMISSION.

VICTORIA, B. C.—The Britannia Power Company is to erect a transmission plant on Britannia Beach, Howe Sound, New Westminister District.

RENO, NEV.—An extension of the Floriston-Virginia City Transmission line of the Truckee River General Electric Company to a substation at Truckee is reported.

REDDING, CAL.—The Northern California Power Plant will extend its power lines from the Balakalala substation at Iron Mountain to the Gladstone mines near French Gulch.

BUTTE, MONT.—R. J. Briggs, of Idaho Falls, is in Butte negotiating for machinery for the construction of a power plant at this city for the Idaho Power and Transportation Company.

BRIDGEPORT, CAL.—The Field of Gold Mining Company, of Salt Lake City, is to install a hydro-electric plant for the transmission of power to the Masonic district and Bodie.

EUREKA, CAL.—The North Mountain Power Company has been granted a franchise for the erection of a transmission line along the public thoroughfares between this city and Arcata.

PRESCOTT, ARIZ.—The Jessie Mines Company, operating in the Chaparral country, will begin the construction of an electric transmission plant to be located on the Agua Fria early in April.

SAN ANDREAS, CAL.—The Stanislaus Mining Company has recently purchased the Duchess group of mines at Callecito, and proposes to install a power plant for the generation of electricity to be used in its operation.

QUINCY, ARIZ.—Solon P. Jacks is authority for the statement that the Western Power Company will vigorously prosecute the construction of their proposed power plant in Butte Valley and Big Meadows during the coming summer.

VANCOUVER, B. C.—The Stave Lake Power Company has resumed the development of the water power of the Stave River Falls which will be electrically transmitted thirty-four miles to this city. The initial installation will be about 6000 horsepower.

HONOLULU, T. H.—The Department of Public Works has appointed a commission consisting of R. H. Trent, H. M. Von Holt and R. A. Peterson which will determine the value of the water rights in Pauoa and Kalihi valleys with the view of their acquirements by the government.

TAMPICO, MEX.—Geo. K. Marsden, of St. Louis, Mo., has been investigating the possibilities of the Tamasi River for water power development for the purpose of installing a transmission plant to supply the surrounding country with electric light and power should the water supply be found adequate.

CITY OF MEXICO, MEX.—Chas. A. Hamilton, who is heavily interested in mines in the state of Oaxacan and who is now erecting a large smelter in the city of that name, has secured a concession permitting the diversion of water sufficient to develop 12,000 horsepower from the confluence of the Miahuatlan and Sola rivers.

ROSSLYN, D. C.—The West Kootenay Power and Light Company, which is under the management of L. A. Campbell, has begun the power development of the upper falls of the Kootenay River at Bonnington, by which the present capacity of the plant at the lower fall, amounting to about 4,000 horsepower, will be trebled or quadrupled.

NOME, ALASKA—The United States Blow Pipe and Hydraulic Works, through the agency of Jamison and Balcom, of Seattle, have been awarded the contract for the installation of 3500 feet of forty-eight-inch rivited pipe to be made of three-fourth-inch steel. This pipe is to be used in the new hydro-electric plant being installed at this place.

MOUNTAIN HOME, IDAHO—J. E. Jerome, J. H. Garratt and W. J. Turner are organizing a company with a capital stock of $500,000 for the purpose of erecting a power plant at Crane Falls near here. Power will be utilized for lighting this place and Bruneau, as well as for the operation of an electric road that it is proposed to build between these places.

PARRAL, MEX.—James Roberts, a rich miner of the State of Durango, has just purchased the San Lorenzo Water Fall, which is situated about twenty leagues from Parrall. The Fall, which is about 200 meters high and can be relied upon to furnish a minimum of 2000 horsepower, will be used for the generating of electric power to be transmitted to his mines thereabouts.

REDDING, CAL.—E. W. Sutcliffe, who is well known in electric railway and transmission engineering enterprises throughout the State, has organized the Battle Creek Power Company, which is erecting a power plant on Battle Creek, in Shasta County, whence power will be transmitted to Oroville and into Yuba County in competition with the Bay Counties system.

BALLARD, WASH.—Frank G. Simpson, general manager, of the Ballard Electric Company, denies any intention of the company to sell its plant to the Seattle Electric Company. Instead the company is preparing to add National Electric generators to its plant to supply power to the Seattle-Everett Interurban Railway Company, which is building a line from Seattle to Everett.

CITY OF MEXICO, MEX.—Pablo Gunther and Joaquin Cortazar, the former of Camargo and the latter of Chihuahua, propose to elect a power plant near Boquilla whence electric power will be transmitted to Boquilla and the neighboring mining industries. It is stated that over $1,000,000 in gold will be expended on the plant and that actual construction will begin by April 1st.

LA DICHA, MEX.—The Mitchell Mining Company, of Los Angeles, Cal., of which Geo. Mitchell, who has offices in the Bradbury Building in Los Angeles, is president, is developing power from the Papagallo River for a transmission plant that will furnish light and power for the towns and copper mining properties of the Mitchell Mining Company hereabouts in the State of Guerrero.

ANGELS, CAL.—The Westinghouse Electric and Manufacturing Company has secured a contract from W. C. Tullock, of San Francisco, for two 750-kilowatt generators which are to be installed on the Stanislaus River six miles above Murphys. These will each be driven by a thirty-five-inch turbine operating under a head of 250 feet, and power therefrom will be distributed through Calaveras and Tuolumne counties.

SALT LAKE CITY, UTAH—Announcement is made that the Utah Light and Railway Company will erect a new power plant on the site of the Granite Planing Mill, Fairfield, Wash. The Washington Water Power Company is planing to build a substation in Fairfield to be operated from the main line of the Spokane-Coeur d'Alene Transmission whence will be furnished electric light and power for Fairfield.

CITY OF MEXICO, MEX.—J. H. Devereux, a mining and electrical engineer of New York, George L. Smith, of Colorado Springs, and A. B. Mason, of New York, are now surveying the route for a transmission line from Cananea to the Junction of the Arros and Bavaspe rivers, 150 miles, where the Cananea Consolidated Copper Company proposes to erect an 80,000 horsepower hydro-electric power plant. It is expected the work will consume two months.

UKIAH, CAL.—The Eel River Power and Irrigation Company has closed a contract for the electric lighting of the city of Ukiah, and is actively prosecuting the work of drilling a tunnel connecting Eel River and Potter Valley. This tunnel will be six feet square, lined throughout with cement, and have a length of about one mile, At its mouth water will be available for conveyance to the power house under a head of 420 feet, storage being provided by a 100-foot dam which, when completed, will back the water up the river for a distance of about five miles.

SAN FRANCISCO, CAL.—The Nevada Power, Mining and Milling Company has awarded contracts for machinery and apparatus to be used in the Bishop Creek-Goldfield transmission as follows: To the Pelton Water Wheel Company for two, two-bearing, 1500 horsepower water wheels to operate under a head of 1024 feet, and also for the installation of 3240 feet of twenty-four-inch lap welded steel pipe which is to be made in Germany; the National Electric Company for two 730-kilowatt, three-phase, sixty-cycle generators; to the Pittsburg Reduction Company for

300 miles of illuminum line wire; to the Booth-Kelly Company of Eugene, Or., for 9000 feet of wood stave pipe varying from forty-two to thirty inches in diameter, and to the Stanley Electric Manufacturing Company for eight, 500-kilowatt, transformers.

FRESNO, CAL.—The permanent lines for the new power plant and reservoir sites in Crane Valley, are being run by G. O. Newman, chief engineer of the Huntington interests. The power house will be constructed at the site of the Banta & Morton mill, the Huntington interests having acquired that property. The ditch line will follow the line of the old French ditch, which was built about thirty years ago. The new power plant, when completed, will enlarge the capacity of the plant one and one-half times and furnish power for the extension of the system to other towns in Fresno and surrounding country—Selma, Sanger, Fowler and Madera among the number. The present reservoir at the head of the power line will run twenty-four hours, drawing direct from the big reservoir in Crane Valley. The construction of the Crane Valley reservoir will be begun this summer and will cover 1200 acres. Plans are being prepared for a substation of the power plant at the Vernoe Copper mines.

TACOMA, WASH.—The White River Plant of the Seattle-Tacoma Power Company, which is under construction, diverts water from the White River about half a mile above Buckley, whence it is taken through a canal having a width of thirty feet on the bottom and fifty feet at the top, with a depth of eight feet, for a distance of five miles to Lake Tapps which will be dammed so as to merge it with Kirtley, Crawford and Kelly lakes. This will give a reservoir area of over 4000 acres which will be flooded so that there may be drawn therefrom a depth of thirty feet of water. The power house will be located within ten miles from Tacoma and will be operated under a head of 485 feet. In addition to the water power of the South Fork of the Puyallup River, Snoqualmie Falls, and the White River, in combination with Lake Tapps, there are many other rivers or streams fed by the glaciers and snows of Mount Tacoma which may be utilized for generating electric power as rapidly as required. In some instances land and water rights have been acquired with a view to their utilization for supplying electrical power to Tacoma and other cities and towns in its vicinity. The Tacoma Industrial Company owns a continuous strip of land four miles in length, including the White River, and has made preparations to install a 15,000 horsepower plant twelve miles from Tacoma. The Nesqually River, which flows into the Sound between Tacoma and Olympia, has enormous undeveloped power resources. About thirty miles southeast of Tacoma, at Le Grand, a station on the Tacoma Eastern, on the brink of the Nesqually Canyon, is an available and easily accessible water power capable of generating 30,000 horsepower. Tacoma commands the use of not less than 200,000 horsepower.

SAN FRANCISCO, CAL.—The Owens River Power and Water Company, of which John Landers is president, and Edson F. Adams, of Oakland, is principal backer, Leon M. Hall being consulting and supervising engineer, is taking active steps toward building a ninety-six-mile electric power transmission from Inyo County, Cal., to Tonopah, Nev., via Goldfield. It is stated that the flow of water controlled by this company is 160 second-feet at the lowest stage of the river and that at another site which may be utilized later the river falls about 1000 feet in a distance of three miles. The generating station is to be installed in the Owens River Canyon, about one and one-half miles below the point where Birchim Canyon cuts into it. The main pole line will run over the mesa and into Round Valley to a point one and one-fourth miles north of Laws, thence to the mouth of Silver Canyon. While a franchise has been secured in Inyo County for the use of the public highways, a private right of way will be followed the greater part of the distance to Tonopah. The specifications will call for two 1000-volt, three-phase, twenty-five-cycle generators, each of which will be direct connected to a water wheel operated under a head of 200 feet of water. There will be four 750-kilowatt transformers at the powerhouse, four 400-kilowatt at the Tonopah substation, and four 300-kilowatt at the Goldfield substation. A redwood stave pipe will conduct the power water from a crib-diverting dam eight feet in height to the power house. This pipe will be 9600 feet in length by sixty inches in diameter. It will built of finished redwood staves two and one-half by six inches in lengths varying from twelve to twenty feet. The pipe will be banded at short intervals with five-eight-inch round iron. The transmission line, of copper wire, will be operated at 50,000 volts.

ILLUMINATION.

LAKEPORT, CAL.—James K. Birch, of San Francisco, has applied for an electric lighting franchise.

PARK CITY, UTAH—Henry Shields and others have been granted an electric lighting franchise.

SOCORRO, N. M.—Elfego Baca has been granted a franchise for the construction of an electric lighting and railway system.

MAYFIELD, CAL.—A number of citizens of this town are investigating the cost of installing a local electric lighting company.

SOULSBYVILLE, CAL.—Nicholas Bros. are actively engaged in building an electric lighting plant which will be driven by water power.

LOVELOCK, NEV.—L. N. Marker has installed an electric lighting plant which will be enlarged later if the venture proves to be successful.

EDMUNDS, CAL.—The Edmunds Electric Light and Power Company are installing an electric lighting plant here, its initial capacity being about fifty horsepower.

EPHRAIM, UTAH—The City Council will probably call a special election to vote upon the issuance of bonds in the sum of $20,000 for an electric light and power plant.

CEDARVILLE, CAL.—H. Hawkins and others propose to build an electric lighting plant to Cedarville and to incorporate a company therefore with a capital stock of $20,000.

CALISTOGA, CAL.—Messrs. Brown & Cutler are installing an electric lighting plant, which will be in operation by May 15th, on the bank of the creek near H. C. Thompson's planing mill.

PAYSON, UTAH—At a special election held on February 18th, it was decided to bond the city in the sum of $12,000 with which to improve and enlarge the Municipal Electric Lighting Plant.

ONTARIO, OR.—Seymour H. Bell and Chas. H. Chance, of Sumpter, Or., are building an electric lighting plant here which will cost about $25,000 and will be in operation by October next.

KALSO, WASH.—The Kalama Light and Power Company, of Kalama, Wash,, and the Kalso Water and Light Company, of Kalso, are applying for an electric lighting franchise for this town.

SANTA BARBARA, CAL.—The Merchants Mutual Light and Power Company, a new co-operative corporation consisting of merchants of Santa Barbara, has been granted an electric light franchise.

GARDNERVILLE, NEV.—The citizens of Sheridan are endeavoring to establish an electric lighting plant at the mouth of Job's Peak's Canyon for the purpose of delivering electric service in Gardnerville.

SANTA ROSA, CAL.—The City Council is considering the advisability of installing a municipal electric lighting plant which the Westinghouse Electric and Manufacturing Company estimates will cost $100,000.

SANTA MONICA, CAL.—The United Land and Water Company, promoters of the new town of Serra Vista, propose to install there an electric light and telephone system together with other improvements of municipal nature.

MONTERREY, MEX.—Work has been begun on the installation of an electric lighting plant of Arbol Grande which will furnish

electric lights for the Arbol Grande docks of the Agencia Commercial and Maritima of this city.

REARDON, WASH.—J. M. McDowell has placed an order through the agency of Nixon & Krinnel, of Spokane, for two twenty-five-kilowatt direct current generators to be used in a steam driven electric lighting plant for this place.

FALLON, NEV.—The Fallon Electric Light Company, by Dr. G. M. Gardner, has been granted the privilege of erecting poles for an electric lighting system provided the operation of the same does not interfere with the telephone system.

EUREKA, CAL.—Ordinance No. 379 has been adopted fixing the price of gas at $2.00 per thousand and of electricity at the rates of 10 and 12 cents per kilowatt-hour according to consumption, besides fixing flat rates for electric service.

SOUTH BEND, WASH.—J. M. Etnier has been granted an electric lighting franchise which will have an initial capacity of 3600 sixteen candle power lamps and be steam driven, the fuel to be used to consist of sawdust taken from the Siler Mill.]

ANAHEIM, CAL.—After more matured deliberation the citizens of this town have concluded that it is advisable to bond the city of Anaheim for $50,000 for the building of a municipal water and electric lighting plant, instead of $15,000 as originally proposed.

HONOLULU, T. H.—Acting under the direction of the Board of Public Works, Municipal Architect Traphagen is drafting plans for the installation of a 150-kilowatt generator and water wheel for the new electric light station that is to be built in Nuuanu Valley.

SAN FRANCISCO, CAL.—Sidney Sprout, the well known electrical engineer of San Francisco, is at present in Culiacan, State of Sinaloa, Mexico, where he is supervising an electric light, electric railway and telephone system for the Culiacan Electric Company.

EUREKA, CAL.—The Eureka Lighting Company has given a contract for the installation of a 750 horsepower steam engine in its Station A which will be supplemented later by a 250 horsepower engine, and in a few months it will install a 500 horsepower engine in its Station B.

TAMPICO, MEX.—The International Land and Colonization Company, which is represented in Tampico by H. E. Diehl, of Lawton, Okla., is opening up a town site at the foot of Gonzales Mountain, which it proposes to illuminate by an electric lighting plant to be driven by water power taken from the Tamesi River.

CITY OF MEXICO, MEX.—The central station of the Mexican Light and Power Company at Nonoalco, which was practically destroyed by fire on February 4th, carried insurance as follows, in pound sterling: Buildings, 31,500; machinery and accessories, 116,000; stock in hand, fixtures, furnishings, exclusive of coal, 3,000; total, £160,500.

PORTLAND, OR.—It is reported that I. W. Anderson, representing Philadelphia capital, which recently acquired the plant of the Salem electric light and the electric plants at Walla Walla, Wash., Hamilton and Baker City, Or., is negotiating for the Grand, Or., plant. It is said that they may acquire the electric plants at Lewiston, Ida., and at Dayton, Wash. The corporate name of the buyers is the Cyrus Pierce Syndicate.

SANTA ANA, CAL.—The City Trustees have enacted an ordinance fixing the prices of gas and electricity furnished consumers within the city limits. The gas rate was fixed at $1.25 per 1000 cubic feet, with a minimum charge the consumer of 50 cents. The rates which were fixed for electricity are taken from the prices charged by the Riverside municipal plant, as follows: Fifteen cents per 1000 watts for first 5000; 10 cents per 1000 from 5000 to 25,000; 6 cents per 1000 above 25,000. Gas prices were formerly $2.00 per 1000 cubic feet, with a minimum varying from 50 cents to $1.00 Electricity rates were based on a sliding scale varying with the amount consumed by different individuals. All the gas and electricity here is furnished by the Edison Electric Company under the local name of the Santa Ana Gas and Electric Company. Officers of the company regard the rate fixed for gas as ruinous, declaring that it will barely pay operating expenses.

SAN FRANCISCO, CAL.—The Board of Supervisors have ordained that for the year commencing July 1, 1905, the legal rate for electric lighting and power services shall be 9 cents per kilowatt hour, from which rate discounts shall be allowed as follows:

On a consumption per sixteen candle power incandescent lamp of 2000 to 3000 watt-hours in one month, 5 per cent.

On a consumption per sixteen candle power incandescent lamp of 3000 to 4000 watt-hours in one month, 10 per cent.

On a consumption per sixteen candle power incandescent lamp of 4000 to 5000 watt-hours in one month, 15 per cent.

On a consumption per sixteen candle power incandescent lamp of 5000 to 6000 watt-hours in one month, 20 per cent.

On a consumption per sixteen candle power incandescent lamp of 6000 to 7000 watt-hours in one month, 25 per cent.

On a consumption per sixteen candle power incandescent lamp of 7000 to 8000 watt-hours in one month, 30 per cent.

On a consumption per sixteen candle power incandescent lamp of 8000 to 9000 watt-hours in one month, 35 per cent.

On a consumption per sixteen candle power incandescent lamp of over 9000 watt-hours per month, 40 per cent.

In estimating the discounts, one arc lamp shall be equivalent to two sixteen incandescent lamps for each ampere of current used by said arc lamp. A charge of $1.50 for the maintenance of a meter during any month may be made to any consumer whose bill for current furnished during such month does not exceed $1.50, but in the event of such charge being made, no further charge shall be made for current furnished during said month to said consumer.

COMMUNICATION.

FULLERTON, CAL.—W. L. Porterfield has been granted a franchise for a telegraph and telephone system.

TORREON, MEX.—The local telephone system is being extended from Monterey to Durango and this place.

SALT LAKE, UTAH—The Utah Independent Telephone Company has secured a franchise over the county roads.

RED BLUFF, CAL.—J. T. Swanson is building an independent telephone line from here to Manton, a distance of fifty-four miles.

SAN RAFAEL, CAL.—J. W. Keegan, of Dillon's Beach, has made application for a telephone franchise along the county road from Tomales to Dillon's Beach.

CITY OF MEXICO, MEX.—The Mexican Telephone Company is to make substantial improvements in its system extending to Tampico, Progresso and Merida.

SEATTLE, WASH.—The Sunset Telephone and Telegraph Company will expend $300,000 in building two branch offices in this city and in making extensions into the surrounding country.

SANTA BARBARA, CAL.—On April 2d the Board of Supervisors will sell the telephone franchises petitioned for by E. R. Vale and the Home Telephone and Telegraph Company respectively.

CLOVERDALE, CAL.—A committee of the Town Council, consisting of Walter Crigler and E. E. Gibbons, are considering the proposition of the Alert Fire Company for the installation of a fire alarm system.

MONTEREY, MEX.—Phil. Head, an electrical engineer of this city, is installing a telephone system connecting the smelter of the Mexico-American Mining and Development Company with its different mines at Valardena.

NAPA, CAL.—Twenty-five subscribers have been secured for a farmers telephone line that is to be built into Brown's Valley. The enterprise is a mutual association of which A. B. Butler is president and F. A. Hein is secretary.

FRESNO, CAL.—An independent telephone line will probably be built from this city connecting with Lone Star, Oleander, Easton and eventually out on the Wild Flower road, a distance of five miles. Address W. T. Crawford, J. R. Kennedy or W. J.

Griffin. The system will probably be incorporated as the Fowler Telephone Company.

SAN FRANCISCO, CAL.—According to the *Examiner*, Henry M. Schneider, of Philadelphia, is making a trip of inspection through Chicago, Omaha, Salt Lake City and San Francisco in the interests of the recently formed New York and New Jersey Telephone Company, capital $250,000,000, which intends, it is stated, to install an overland telephone service by New York and San Francisco.

TUCSON, ARIZ.—Rumors are current that the Consolidated Telegraph and Telephone Company, of Arizona, of which Epes Randolph is manager, has perfected negotiations toward the consolidation of all independent telephone lines in Arizona, the new system to become a part of the American Telephone and Telegraph Company. The Arizona system will be connected within a few months with the California system and with Eastern lines at El Paso. Tex.

WATER WORKS.

SMITHFIELD, UTAH—An effort is to be made to bond the town for $9000 with which to build a water works.

CORONA, CAL.—The Temescal Water Company is to install a 3000-foot steel flume between Corona and Temescal.

KENNETT, CAL.—Private capital is installing water system to supply the smelter and town of Kennett with water.

VALLEJO, CAL.—On February 28th, the electors of the town voted favoring the issuance of $90,000 in water bonds.

PROVO, UTAH—The City Council is considering the question of bonding the city for building a water and electric light plant.

ORANGE, CAL.—The S. J. Smith Company, of Los Angeles, has been awarded a contract for the installation of a water system.

WHITTIER, CAL.—On March 14th water bonds to the amount of $100,000 were voted for the construction of a municipal system.

ORANGE, CAL.—An ordinance has been passed to print providing for an issue of $50,000 in bonds for the installation of a water system.

ANDERSON, CAL.—The Anderson Water Company is sinking wells in the endeavor to find an improved source of water supply for the town.

PETALUMA, CAL.—The Petaluma Water and Power Company is to lay new water mains consisting of 700 feet of six-inch pipe and 800 feet of two-inch pipe.

SAN DIEGO, CAL.—The City Attorney is preparing papers for an ordinance proposing the bonding of the city to acquire the water works at El Cajon.

SPARKS, NEV.—It is reported that the Nevada Power, Light and Water Company will run a pipe line from Reno to supply the town of Sparks with water.

SAUSALITO, CAL.—The proposition to bond the town in the sum of 100,000 for a municipal water works was defeated at the election held on March 6th.

LOVELOCK. NEV.—A bill has been introduced in the Assembly providing for the bonding of the town of Lovelock in the sum of $2000 for a local water works.

SAN JUAN, CAL.—An ordinance has been submitted calling for an election to bond the town for not in excess of $6000 for a municipal water works system.

PASADENA, CAL.—An ordinance has been introduced calling for a bond election for a new water system in the amount of $1,000,000 bearing 4 per cent. interest.

BLAINE, WASH.—A water franchise has been granted to H. L. Jenkens of the Jenkens Lumber Company, a Minnesota corporation, with a capital stock of $1,000,000.

SANTA ANA, CAL.—The money available from the $100,000 bond issue is to be expended as soon as expedient in making necessary improvements of the municipal water system.

SANTA BARBARA, CAL.—Upon recommendation of the water commission it has been decided to advertise for bids on an additional issue of $40,000 water extension bonds after May 1st.

BISBEE, ARIZ.—The Huachuca Water Company, through its representative, A. H. Gardiner, is beginning the construction of a twenty-four mile pipe line to extend from Bisbee to Lowell.

VENTURA, CAL.—The special election is to be held on April 22d to vote on an issue of $100,000 for a water works system $25,000 for an electric light and power plant and $10,000 for sewers.

SALT LAKE CITY, UTAH—The Mutual Life Insurance Company, of New York, has bought $850,000 in water bonds and $150,000 in sewer bonds at par with accrude interest and a cash premium of $15.100.

TACOMA, WASH.—On April 4th a special election will be held for the purpose of bonding the city for the construction of a municipal water system using air lift wells and to cost about $40,000.

TUCSON, ARIZ.—The City Council proposes to call an election to vote upon an issue of $250,000 in fifty year bonds, the proceeds from the sale of which are to be used in improving the municipal water system.

SANTA ROSA, CAL.—The bonding of the city in the sum of $200,000 "for a Greater Santa Rosa" is to be submitted to a special election and if carried $72,500 will be expended on the municipal water plant.

OAKLAND, CAL.—The election held on March 11th resulted in the overwhelming defeat of the proposition to bond the city for $1,950,000 for the purchase of the water system proposed by the Bay Cities Water Company.

SEBASTOPOL, CAL.—The Town Trustees have declared their intention to hold an election for bonding the city in the sum of $60,000 for improvements, among which $37,000 will be devoted to the building of a water works.

JUAREZ, MEX.—The Government at Chihuahua is soon to advertise for bids for the construction of a system of water works for Juarez in which 500,000 pounds of six-inch and eight-inch water pipe is to be used. Its estimated cost is between $70,000 and $100,000.

YREKA, CAL.—The city of Yreka obtains its supply of water for domestic consumption from a stream brought four miles from town where a concrete dam was built to Bedrock, enabling a subterranean catchment. The water is piped thence to a reservoir situated about a mile from town from which it is delivered under a head of 200 feet.

MONROVIA, CAL.—A special election is to be held on April 19th to vote bonds for public improvements among which appears items for the purchase of water bearing lands, the development of water therefrom and the building of a water system, $15,000; the purchase of a 100 horsepower A. C. motor and a 1000-foot air compressor, $6500; a 150 horsepower A. C. motor and single acting triplex pump, together with considerable iron and cement pipe.

SANTA BARBARA, CAL.—The city of Santa Barbara owns its water system and water supply, which system was started in 1898 by tunneling into the mountain. It has steadily increased its system, and at the present time has thirty-three and a half miles of mains laid in the city, ten miles of which have been laid within the last year. The number of taps on the main is 1247, and the number of consumers at the present date 1150. The receipts from the sale of water to consumers for last year were $22,374.50 and water supplied to the municipality $7456.80. The total cost of the system, including tunneling, from its commencement on July 1st of this year, was $239,613.82. $200,000 in bonds at 4½ per cent. have been voted on, $40,000 of which have been sold, and the balance will be put on the market as necessity demands. The profit from the sale of water pays the interest on the bonds at present, and is calculated to do so in the future, as extensions now in progress are completed.